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EDUCATION

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HANOR A. WEBB, *Editor*

Chairman, Division of Science and Mathematics
George Peabody College for Teachers

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EDUCATION

Vol. 65 MARCH, 1945 No. 7

"Research studies in the area of aims and objectives of science teaching indicate a trend toward the practical and concrete."—BLICK.

Recent Trends *in* Research *on* Science Teaching

By DAVID J. BLICK[1]

Introduction:

THE first published studies in the teaching of science were made approximately thirty-five years ago. Prior to that time, no experimental evidence was available concerning the selection or organization of the material composing the science curriculum or the methods used in instruction. Since then, however, nearly every phase of science teaching has been the subject of some research consideration.

Research may be defined as the total procedure employed in collecting, handling, and interpreting data for the purpose of arriving at dependable answers to problems.[2] This definition may be extended to include the philosophical or deliberative type of inquiry which proceeds from a point of view and is concerned with "what should be." Research is characterized by: an adequately defined problem and locus (in the philosophical type of inquiry a locus may or may not be present); a systematic procedure; the securing of as accurate and valid data as possible (it may be necessary to use subjective techniques, especially in the philosophical type of inquiry); a recognition of the limitations of the data and the statistical procedures used in arriving at conclusions; and the interpretation of findings in terms of general conditions and relationships (social validity). In gathering data the following techniques have been widely used: the use of public records and published or unpublished sources; the analysis of textbooks; the interview and case study; the questionnaire; the scoring scales and cards;

[1] *MR. BLICK, an instructor in chemistry at the University of Connecticut, Storrs, Conn., shows ability in organizing and summarizing educational material that promises well for his future contributions to educational literature. In collaboration with his dean, Dr. C. B. Gentry, he has mimeographed a comprehensive fourth "Digest of Investigations in the Teaching of Science," adding to the notable three "Digests" of Curtis.*

[2] Monroe, W. S. and Engelhard, M. D., "The Scientific Study of Educational Problems," Macmillan, New York, 1936.

the selection and administration of tests; and the judgment of experts.

The following types of research have made up the bulk of the studies reported in the teaching of science: historical—the study of the past, "what has been"; measurement—the construction and validation of tests and other measuring instruments; survey—the determination of the status of conditions and practices, interest studies, etc.; experimental—the determination of the effectiveness of teaching procedures, and the determination of the difficulty level of scientific concepts and subject matter; prediction—estimates of future accomplishment; philosophical — "what should be," based on activity analyses, consensus of opinion, etc. It is obvious, however, that many of these types of research may be combined and utilized in the study of a given problem.

Research in science teaching can be conveniently classified into six major areas: aims and objectives, content and organization, methods of teaching, measurement of the results of instruction, aids to teaching, and the education of the science teacher.

Research On Aims and Objectives:

The aims and objectives of science education generally proceed from a philosophy, and as such they lend themselves to the philosophical type of inquiry. Much of the literature in this area represents individual opinion or consensus of opinion of experts serving on committees. A study of these articles will reveal that many of the statements of aims are so general that they are not practical guides for teachers.[3]

On the elementary school level, the trend in aims and objectives of science education seems to be away from emphasis on subject matter areas and toward the development of desirable habits and attitudes of social behavior. "The tendency to place emphasis on the acquisition of bits of information is giving place to a recognition of the contributions of science to the welfare of individual children and society."[4] In a study to determine the knowledge of science possessed by pupils entering the seventh grade, Matteson and Kambly (33) administered a free-response test of 199 items to 573 pupils. They arrived at the conclusion that "there is little difference between scores of the pupils who were and those who were not taught science in the elementary grades," and "there is no evidence which indicates that the topics included in the tests have been covered 'adequately' in elementary school."

On the secondary level, pre-induction courses and other specific war training courses of a technical nature have brought new emphasis to bear on specific subject matter areas and have led to a new stressing of subject matter. This trend appears to be durational and may lose ground after the war. On the other hand, there has been the trend of many leading educators toward the directing of attention to areas of omission in education which have been revealed by the present war emergency.[5] The following aims to meet the needs of youth in

3 Noll, V. H., "The Teaching of Science in Elementary and Secondary Schools," Longmans, Green and Co., New York, 1939, Chapter II.

4 "Report of the Workshop for Science Teachers. Teachers College, Columbia University, October, 1944, p. 17.

5 "The Education of the Science Teacher," Published by the American Council of Science Teachers of the National Education Association of the United States, Washington, D. C., 1942.

the post-war world have been proposed (39): good health and physical fitness, work experience, comprehension of the natural resources of the nation, comprehension of the impact of science and technology on our society, the ability to select and use the materials made available by science in solving social problems, and consumer education.

Hunter and Spore (22) conducted an investigation on a nationwide basis in which they gathered data concerning objectives of science actually being used in secondary schools. Their data lead one to conclude that the majority of the science teachers do not seriously consider many of the objectives which are receiving most emphasis by leading educators today.

It is interesting to note that while the teaching of "scientific attitudes" as a major aim of science education is still held by many teachers and educators, there is little experimental evidence available to justify the emphasis placed upon it during the last decade. (4, 13, 40, 42, 49, 52).

On the college level, a trend has developed towards giving survey courses in science to students who do not expect to major in scientific subjects. Geer (16) compiled data on the aims and objectives of physical science survey courses in 112 institutions including 56 colleges, 23 teachers colleges, and 23 junior colleges. Hard and Jeans (19) conducted a survey to determine the number, the nature, the content, and the method of organizing and conducting natural science survey courses in institutions of higher learning in the United States. Watson (48) made a study of the growth of survey courses in physical science in high schools and colleges.

Research On Content and Organization:

In the teaching of science in the elementary school, the difficulty level of science concepts and the various meanings which students at the various grade levels associate with them have been studied. Bailey (1) and De Lano (8) have shown that certain concepts cannot be satisfactorily developed with elementary school students and that grade placement of all important concepts should be made. Winters (50) in an extensive investigation concluded that many "meanings" are not adapted to the level of the students and that mental age levels should be considered in formulating the partial meanings of concepts which are taught at the various age levels. These studies support the findings of Matteson and Kambly (33). Thurber (46) draws attention to some frequently neglected aspects in planning a course of study in elementary science courses. Sisson (44) found that the content of any one elementary general science textbook was not a reliable source of information as to what to teach.

On the secondary school level, studies have been made of the difficulties encountered in reading science materials (25, 29). Wise (51) made a study of the relative importance of principles of physical science for general education. Chrisman (6) attempted to determine the social usage of the subject matter content of high school physics. Studies have determined the kind and amount of science appearing in the newspapers and magazines (9, 36), and many analysis of

the content of science textbooks continue to be made (11, 12, 23, 37). Interest studies have received considerable attention (53).

In regard to the organization of high school science, Watson (48) reported a rapid growth in science survey courses. Hunter and Spore (22) in a study of 2,200 high schools reported many new courses such as "Senior Science" and "Consumer Science." Hunter and Parker (21) found "there are considerable differences in the make-up in subject matter of the general science courses in the various areas of the country." The subject matter and organization of high school chemistry have been studied extensively (18, 43).

On the college level there is a trend toward better selection and organization of the content of science courses (4, 7, 16, 34). There is some indication that colleges are attempting better to meet the needs of students.

Research On Methods of Teaching:

Investigations on methods of teaching on the elementary, secondary, and college levels make up an important part of the literature on science education. The secondary level still appears to be receiving the most attention, but there appears to be a trend toward more experimentation on the college level. The college level of science instruction offers wide opportunity for research as there is little experimental evidence for the choice of much of the subject matter included or the procedures by which it is presented (2, 7, 15, 34, 38).

In order to meet the needs of youth better, the "community-approach" has been proposed and developed by prominent science educators.[6] We can expect an increased number of experimental studies to determine the effectiveness of this method of teaching youth to be prepared to meet the demands of our changing society (10, 17, 28).

One of the most common techniques used in determining the effectiveness of teaching procedures involves control and experimental groups. Recently, however, serious doubt as to the value of the findings of this technique has arisen.[7]

Research On the Measurement of the Results of Instruction:

In the field of science education new emphasis has been placed on the measurement of the results of instruction. This trend has been due in part to the deficiencies in the present educational system that have been revealed by the war emergency, and to the more critical attitude of the better prepared teachers of science. For too long, changes have been proposed in methods of teaching and organization without valid experimental evidence that such changes would be improvements.

The trend for better objective testing in the field of science that was inaugurated in the early twenties is still gaining momentum. Especially on the level of college instruction, new and better objective tests are appearing. Progress is also being made in the more objective measurement of desired outcomes of instruction, such as attitudes, ability to apply generalizations, changes in behavior, etc. (14, 26, 47, 49). New techniques are being developed for the prediction of future accomplishment (20, 30). This

6 "Teachers College," 45, January, 1944, (Special Science Issue.)
7 "Editorial Comment," "Education Research Bulletin," 23, 1, 1944, p. 23 (January.)

phase of research has great implications for the proper guidance of youth. Hunter and Spore (22) found that the majority of teachers are making but little use of the newer types of evaluation.

Research On Aids to Teaching:

The effective use that the military forces and industrial concerns have made of audio-visual aids in teaching large groups of people in specific skills has forcibly brought to the attention of the schools the value of such aids to instruction.

Maneval (31) and Krasker (27) made studies of the value of sound motion pictures. Stewart (45) reported on teacher-pupil appraisal of 150 science and mathematics films. Brechbill (3) studied the value of the microprojector in comparison to the individual microscope. Brewer (4) and Carpenter (5) studied the use of radio in science instruction; Dunbar (12) made a study of the changing conceptions of teaching aids in high school chemistry textbooks; and Kambly (24) and Neal (35) studied science textbook illustrations. Many other studies have been made.

As soon as facilities become available after the war, it is likely that much research will be undertaken to determine the best use of many teaching aids.

Research On the Education of the Science Teachers

To attain the more recently proposed aims and objectives of science education will require more competently trained teachers (39). It is no longer considered sufficient for the teacher to be prepared only in subject matter to be passed on to pupils in diluted form. There is a great need for objective research to determine the most desirable preparation for the science teacher. At present, the majority of the requirements included in the curriculum for the preparation of teachers are based upon consensus of opinion. Studies have been made of skills needed by the science teacher (32, 41). We may expect new techniques to be developed in research studies to determine programs which will give the prospective science teacher the background so necessary if general education is to be effective.

Summary of Trends in Research:

1. There have been fewer studies made in the teaching of science in recent years. This is due in part to the effect of the war, but this trend was in evidence before 1940.

2. The studies that have been reported are in general of better quality. There is a more critical attitude on the part of investigators, and a better recognition of the limitations of the techniques of investigation.

3. There appears to be a trend away from the historical type of research which was so popular twenty years ago.

4. Research studies in science education continue to embrace at least six major areas, and nearly every phase of science instruction is receiving some attention.

5. Research studies in the area of aims and objectives indicate a trend toward the practical and concrete.

6. In the area of content and organization, research studies indicate a continuation of the trend to meet the needs of students better on all levels of science instruction.

7. In the area of methods of teaching, there appears to be a trend toward

more research on the elementary and college levels of instruction.

8. In the measurement of the results of instruction, there appears to be a trend to develop new techniques to determine more objectively the so-called "intangibles," such as attitudes, ability to use principles, changes in behavior, etc. New techniques for the prediction of future accomplishment are being developed.

9. In the area of aids to teaching, there appears to be a trend toward intensified and critical study to determine the usefulness of such devices.

10. Most of the research on the education of the science teacher has been based upon consensus of opinion. The need for a more objective determination of the values of training programs is indicated, but this is an extremely difficult area which may have to await the discovery and perfection of new techniques.

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The National Science Teachers Association *as a* Force *for the* Future

By PHILIP G. JOHNSON[1]

Introduction

THE National Science Teachers Association[2] has met all the conditions for the complete merger of the American Council of Science Teachers, a department of the National Education Association. and the American Science Teachers Association, an affiliate of the American Association for the Advancement of Science. These conditions were established at a meeting of representatives from twelve organizations of science teachers who met in Pittsburgh on April 1 and 2, 1944. The merger became official early in October when the Governing Rules drafted in Cleveland on September 15th were approved by a mail ballot received from these same directors. These actions brought to a realization the hopes that leaders in science education have cherished for a half century, namely, a single major national organization for the promotion of better and more science instruction in the schools of the nation.

[1]*DR. JOHNSON, Assistant Professor of Rural Education in Cornell University, Ithaca, N. Y., has long been active in science teachers' organizations. His wise counsel had much to do with the satisfactory merger of two large groups, and made him the logical choice as the first President of the N. S. T. A.*

Support For Science Projects

The National Science Teachers Association is founded upon the premise that a very large number of Active members from all states and territories will provide the most effective means of reaching science teachers and through them, pupils and parents. Therefore the basic membership fee has been established at $1.00 per year. Since there are more than 50,000 science teachers in the United States it seems reasonable to plan for more than 10,000 Active Members. This basic membership fee is so low that it is necessary to supplement the income by other types of memberships. This is provided in Sustaining Memberships at $5.00 a year and Life Memberships at $150. It seems reasonable to plan for at least 500 such members.

There are many commercial and semi-professional organizations interested in more effective science instruction for the youth of the nation. Sometimes their interest is due to their business of selling supplies, equipment, books or related materials for use by students and teachers. At other times, the interest is due to a conviction that a scientifically minded pub-

2 Those who desire a complete discussion of The National Science Teachers Association, its Platform for Action, History, and Governing Rules, may secure a brochure containing such information from the Dr. Johnson.

lic will purchase their products for personal use. In other cases it is based on the knowledge that young men and women need a proper scientific training in order to fill positions in the production and research divisions of their organizations. Because of these and related ideas such organizations are willing to support a number of services related to science instruction.

Commercial or semi-professional organizations often provide speakers for teacher groups as well as for demonstration lectures in high school assemblies. They issue pamphlets, charts, films, service leaflets, exhibits, and employ special staffs to see that their materials get to teachers, pupils and parents. Sometimes they issue medals or scholarship awards and expend sizable funds in promoting the development and discovery of young persons with scientific promise. These same organizations are sympathetic with any plan whereby science teachers, science pupils and the general public can be reached. Their sympathy is real enough that they will support financially such a plan in order that it may grow in scope and influence. For these organizations an Institutional Membership, without any special privileges, is provided.

With the financial support indicated in these types of membership and the advertising in the official journal, it should be possible to soon establish and maintain a national office with a full-time executive secretary and some office help. Through such full-time service there may develop not only the usual services of a magazine and a yearbook, but also special support for projects which will bring science workers together in conferences and committees and through such cooperative work, will bring about special publications for advancing the science front.

Thus, with mental, physical and financial support, there may be developed a continuous attack on persistent problems which plague science teaching as well as strategic offensives against trends, which, if continued, would undermine a constructive science program.

The Plan of Action

Science teachers have had no single national organization with support adequate to meet the persistent problems of science teaching. The developments of a wartime period have focused our attention on certain special problems of science instruction. Thus there has developed a substantial backlog of problems facing science educators.

The Directors assembled in Pittsburgh for the reorganizational meeting discussed this topic and prepared an outline representing the problems which need special attention. These problems constituted a Platform for Action.

The organization shall formulate and promote the adoption of:

BASIS FOR A PLATFORM OF ACTION FOR THE NATIONAL SCIENCE TEACHERS ASSN.

1. A complete and substantial program of science instruction in grades 1 to 12.

2. A program of science studies in colleges designed to provide an adequate liberal education.

3. Standards for the recruitment, selection, training and certification of science teachers and the adoption of these standards by appropriate groups such as boards of education, educational administrators, and teacher-training institutions.

4. Policies and standards in respect to:

   a. individual laboratory work
   b. apparatus and equipment
   c. science textbooks
   d. radio programs in science
   e. Science clubs and other extra-curricular activities
   f. visual and auditory aids to instruction
   g. the discovery and development of science talent in schools and colleges
   h. the coordination of materials of instruction developed by various federal, state and other agencies.

5. A program of courses and activities in science for secondary schools designed to make maximum contributions to the war effort on both military and home fronts.

6. A suitable program of science studies for men and women returning to civilian life from war occupations and for those who may constitute the armies of occupation.

7. A program of science studies for adults.

8. A policy in respect to a possible year of national service which may be required of all boys and girls.

9. A plan for decreasing the lag which now exists between the developments in the science and industrial laboratories and the work in science classrooms.

10. Policies in respect to other educational problems such as:

    a. the coordination of vocational and general education in schools and colleges
    b. the health of the nation
    c. the betterment of international relations through science teaching
    d. the betterment of intercultural relations through science teaching
    e. the importance of conservation of our natural and human resources
    f. science for leisure—time activities
    g. the utilization of science for the solving of human problems and for human betterment
    h. programs for guidance
    i. proposals for consumer education

It must be obvious to anyone that many of these problems cannot be solved once and for all. On the contrary, many of them represent persistent problems which must be studied continuously and the best answers passed on from time to time to teachers and school officials. In this group, for example, we might place a program of training for science teachers and listing of desirable teaching equipment. The National Science Teachers Association is working in standing committees on the study of these problems. There is a need for workers to undertake the study of other persistent problems.

A number of the problems are new either in content or degree of emphasis. They represent places in the educational program where science teachers are meeting a forked road or a blocked road situation. In these areas there is a need for immediate study and action. As examples, we may include Health Education and Consumer Education in this group. The National Science Teachers Association has arranged special committees for such problems and reports are being prepared. There should be additional special committees at work on other problems.

There are other problems facing science teachers. Their definition and publication represent the first step in working out a solution. The National Science Teachers Association is encouraging science teachers to discuss their problems both in conferences and in published discussions. Through such means, new problems or a change in emphasis on other problems may be sensed and defined with the idea that their study and solution may soon be undertaken.

Initial Accomplishments and Plan For the Future

I. Consumer Science:

Coincident with the completion of a draft of Governing Rules in September, 1944, there was held a meeting of a national consumer science committee. This was made possible by a special grant of $750 for the development of a report on Consumer Science. Plans were defined for the production of a report. Soon after this meeting science education workers and teachers interested in science development at a number of major institutions were invited to prepare reports.

Two of these reports were given at a special Consumer Science program arranged by the National Science Teachers Association and presented in conjunction with the meeting of the Central Association of Science and Mathematics Teachers in Chicago on November 24th. Two other reports were prepared by teachers in New York City. One graduate seminar at a major university developed a report.

These reports were studied by one or more members of the central committee. A science teacher with considerable experience in writing was selected to prepare a tentative manuscript from these reports and from additional sources of information. This tentative report will be duplicated and distributed for study by all science teachers who participated in its preparation plus as many others as demonstrate an interest in making constructive suggestions to help in the preparation of the final manuscript.

The financial support and associated services provided by the National Office give promise of the distribution of this report to all members of the

National Science Teachers' Association. Its influence on science studies for all American youth should be very substantial. Many other similar projects should be sponsored by the Association in the years ahead.

II. Joint Meetings:

The National Science Teachers' Association met with the National Association of Biology Teachers in Cleveland last September and held a meeting in cooperation with the Central Association of Science and Mathematics Teachers in Chicago last November. The Middle States Association of Science Teachers encouraged joint planning with the New Jersey Science Teachers' Association. The New York City Federation of Science Clubs and The National Science Teachers' Association for a meeting in New York City last November 25th. A strong program was developed and in the planning of this meeting there was demonstrated an example of cooperative action in the interest of better and more science teaching.

It is a challenging possibility to contemplate such cooperative action looking toward future programs for science teachers in all sections of the nation. The National Science Teachers' Association is committed to a policy of encouraging and assisting in such cooperation without undermining the autonomy of any participating group.

III. Yearbooks:

A Yearbook on science teaching has been issued annually since 1935. In recent years this has been made possible by combining the yearbook with the fall issue of the magazine. Since meetings of science teachers have been greatly curtailed, this yearbook has been the means of bringing the ideas of military and civilian leaders to the attention of many science teachers all over the nation. The titles of the two most recent yearbooks: Pre-Induction Training (1943) and The Influence of the War on Science Teaching (1944)[3] give testimony to the types of discussions which these yearbooks have provided. Plans are already well under way for the 1945 yearbook on Science Instruction for National Security which is scheduled to appear in October, 1945. These yearbooks have provided a meeting-by-mail for thousands of science teachers. The continuance and expansion of this service should be fostered by the Association.

IV. Symposia:

Many scientists, science educators, and classroom science teachers have felt that the sciences have not been given a proper opportunity to serve our peoples. They contend that much pseudo-science has come into the schools through read-about, talk-about types of courses involving science content. Numerous persons have complained that there is an insufficient appreciation for the ways in which the sciences can serve our peoples. Some even contend that we have given our youth too much instruction in the sciences and that the school program should provide for more cultural courses.

The officers and directors of the National Science Teachers' Association have regarded such ideas and some of the trends in science instruction as of major importance and have resolved to do something about them. In brief,

3 These yearbooks may be secured from the National Education Association, 1201 Sixteenth Street, N. W., Washington, D. C., at 50c each.

they have resolved to plan a major symposium on The Place of Science in American Education as the 1945 program of the Association at its meeting with the American Association for the Advancement of Science. Outstanding leaders among scientists, educators, industrialists, and other groups appreciative of the importance of the sciences will have a part in the Symposium and the plans call for a publication of these materials as a major publication which all educational workers may study in efforts to guide the development of science programs in the schools of the nation. From time to time similar symposia should be planned by the Association to give an appropriate direction to development of the sciences in education.

The Magazine:

The National Science Teachers' Association has decided to use *The Science Teacher* as its official publication for the present. Four issues a year are now published and delivered to all members of the Association. As soon as income and leadership is available it is possible to add issues until a monthly magazine is available. Whether or not the Association will continue to use The Science Teacher or establish its own Journal remains for the future Boards of Directors to decide, the National Association should, however. operate its own Journal whether this is made possible by some consolidation of existing journals, the expansion of its present magazine, or the development of an outstanding new journal.

A National Office:

Up to and including the present the Association has been operated on borrowed time. A few persons, who have been keenly aware that this period is crucial in the shaping of science teaching in the future, have been giving time, thought and money to perfecting a working organization. Mistakes have been made and services to members have sometimes been slow and accompanied with errors. It should be known that no expenses for travel, or regular secretarial help, and no remuneration of any kind has been provided by the Association. This has been the condition in the Sciences as these relate to precollege education but it has not been equally true in other subject matter areas. Some other subject matter areas have long had national headquarters with full-time executive leadership.

If we are to make our Association a Force for the Future we must be unselfish enough to support the Association by money and service. Our financial resources through personal and group dues, sale of regular and special publications, advertising, gifts, and grants, should provide revenue for the operation of a vigorous headquarters and also assist committees in the study of both the persistent and the unique problems.

Summary

The National Science Teachers Association represents the closest approach to a unified plan for action that science teachers have made. With personal and professional unselfishness the Association may achieve a plan for intelligent democratic action second to none among the various subject matter areas.

There are many persistent problems worthy of continuous study by science teachers. There are also some unique problems whose solution may change

strikingly the nature of science instruction in the future. New problems or a new emphasis on older problems are also coming to be sensed. The Association has begun to encourage a study of a number of problems, but greater financial resources and a greater willingness to give time and thought to such problems must be made available than has been true in the past.

A National Association cannot come to be a major Force for the Future in a year or two. Furthermore, it is in constant danger of becoming a tool for the promotion of some philosophy of science education, or some group may, through design or necessity, come to dominate the Association. Aloofness on the part of groups of science teachers or on the part of science teachers themselves will not avoid these dangers; on the contrary, a lack of cooperation will promote the very things which are now feared by some persons.

The National Science Teachers' Association is the realization of our hope for an agency to promote better and more science instruction in the schools of the nation. Let us all be generous in our gifts of time, thought, energy, and money so that this plan may prosper. The Association can become a genuine and constructive force for the future. What is will become will be determined by the science leaders and science teachers of the nation.

"Education, like every other institution, has learned a good many lessons in the wartime conversion to wartime service. In science education we have learned to make fuller utilization of our facilities; we have had to meet the demand for an accelerated pace of study; we have had to adapt our curriculums to include wartime information; we have observed the armed forces' effective use of visual aids, streamlined programs, concentrated adaptation of materials, and the extensive testing program. From these many wartime examples, post-war education should be more efficient, more functional, and more effective."

—Emil L. Massey in *The Science Teacher.*

"Already the 150,000 boys and girls in the 7,000 clubs of the Science Clubs of America constitute the largest science organization in the world."—DAVIS.

Science Clubs *of* America— *An* Educational Force *for the* Future

By WATSON DAVIS[1]

WHAT grass roots are to agriculture, science clubs are to science education. These bands of boys and girls are a perpetual youth movement, constantly renewed by the innate and undulled curiosity and exploratory spirit of those who are discovering, through doing, the world about them.

If the future belongs to youth and to science, then there is a vastly more important place for science clubs in the scheme of things that are to be. Except that it is now given purpose, aid and encouragement through tools and programs, this ganging-up of those who want to find out about nature, machines and stuff is not a very new phenomenon.

Boys have had their workshops in barn and basement. In pioneer American days the whole struggle for existence was one big experiment and the children played their early and practical part in it. Girls, too, are no new hands at this business of experimenting, except that during certain decades getting feminine hands dirty was not fashionable. But there was always the tomboy, at that.

Today it is recognized that science education must be accelerated if our growing boys and girls are to recapitulate the scientfic history of the human race in the few years between entering school and getting to or through college. The formal science classes in graded, junior high and senior high schools do their part; it is a large share, too, if the pupil is fortunate enough to have a well-informed, enthusiastic and tolerantly skeptical teacher.

The informal science clubs, squeezed in after school with the help of a teacher-sponsor, or the equivalent gang that makes models, or builds a radio set, or does chemical experiments, or collects insects, getting together in the precious free time left after school or on Saturdays and Sundays — these groups have quite as much educational value and purpose as the 9 to 3 (or whatever it is) schedules.

Before this war we heard a lot about leisure time activities, and I used to wonder even then how that sounded to these boys and girls who are always busy and never have time to do all they wish to do — quite like some of their grown-up friends even when there was not a war to be won!

Adults may underestimate the capacity and the magnificent drive of

[1]*DR. DAVIS, Director of "Science Service," Washington, D. C., has greatly broadened the original purposes of his organization to serve the nation's newspapers, and is now a most active and resourceful sponsor of science for youthful students. The most recent Science Service publication is the popular monthly bulletin "Chemistry"—have you seen it?*

the teen-agers, and I found myself wondering whether rules limiting a pupil to only one extra-curricular activity, forcing a choice between science club and orchestra, for instance, were really wise. How would a future Einstein choose?

With so much depending upon the development of every brain of our nation's science talent, everything should be done that can be done to bring to fruition the scientific ability that exists throughout the breadth of our land. If we fail to have a creatively effective application of science and technology to the problems of the world, we shall not be able to remake the world after the strain of war and disorder. We shall not be able to protect ourselves against the forces of ignorance, brutality and insanity that have tumbled into bloody ruin so much of our civilization. We shall not be able to rebuild our own land for all our people, and we shall not be able to aid other peoples to build better lives for themselves.

If there were doubts about the necessity of scientific research and the application of science to industry and life, those must now be dispelled by the service of science during this war. Greatest are the advances of medical research that save lives that high-explosive shells try to take. Penicillin, sulfa drugs, new wonders from blood, DDT, and a score of other research developments are achievements that are on the black ink side of humanity, offsetting the red of new weapons, whether devised by our enemies or by ourselves. When we no longer have to fight for our lives, what a world we can have!

The science club, a group of 20 or 25 boys and girls encouraged by a teacher or some other sympathetic person, is a seed organization. Each one is precious. Each eager young scientist must be viewed as possibly joining that procession of scientists through the centuries who have been innovators in our civilization, although they are, the best of them, just plain folk in ordinary ways.

Our great problem is to see that these potential scientists of tomorrow have a chance to show their worth. We must see that they are not submerged in complacent ignorance and negativeness.

The science club is an intensely local phenomenon. City, regional, state and national organization can help and encourage, but it is the boy or girl who must do the job.

A great science movement is in the making. Already the 150,000 boys and girls in the 7,000 clubs of the Science Clubs of America constitute the largest science organization in the world.

To these clubs there now are sent a flow of motivating materials—pamphlets, programs, lists and suggested projects. They can have — but are not required to have — the paraphanalia of organization such as membership cards, pins, etc. Government research bureaus, societies and industries invite them to conduct cooperative research projects. They may have, through their local newspapers and through Science Service publications, access to reports of the progress of science. Books and experimental kits are fashioned for them that they may learn with accuracy and without loss of time. Within their states and cities there is aid, organization and encouragment from science academies and school systems.

The annual Science Talent Search for the Westinghouse science scholarships is an attempt to spot those in the high school senior classes who have the stuff of great researchers. The colleges of the nation have been alert to do their best to afford unusual opportunities to those selected.

This is only a beginning. The ever-changing ranks of Science Clubs of America should double or triple. There should be at least one science club in every high school. State and local science "fairs" will provide incentive for many more projects. War surplus materials should give the clubs rich and useful things to use in their experiments. In every field of science the books, the movies, and the experimental material will be more available and more effectively presented.

Because science is a mode of thought and a method of life, the new educational force of science can make itself felt much earlier than the high school. The gang instinct that gives rise to clubs may not be effective earlier than at about the junior high school age, but even in the nursery school the beginnings of science — stars, snow, rain, birds, insects, heat, babies, and a thousand other subjects — can be studied in the effective informality of modern education. Much of the so-called general science of the present high school years will be covered quite naturally in the grade schools.

If Johnny and Mary have such fun with science in their science clubs, there may be some hope that older folk will tumble to the fact, as thousands upon thousands have already done, that science is a good hobby. The age range for science clubs is nine to ninety. That may well give science in the coming years its greatest educational force.

"Civilized man has enveloped himself in an artificial environment, thereby bestowing upon himself certain benefits. But, with these advantages, have come psychological problems. The same intelligence that man used to modify his surroundings he can use to adjust this environment in such ways as to resolve his conflicts — that is, to make himself happier."

—Joseph Singerman in *The Science Teacher.*

"An idea is not validated by its antiquity—nor by its novelty."—GRUENBERG.

Some Troubles *of* Young Science Teachers

By BENJAMIN C. GRUENBERG[1]

A VERY bright high school girl learns all the lessons in General Science, gets high grades, knows all the answers. In every way she's a very satisfactory pupil; good personality, too. At the end of the term, however, she writes on her examination paper, after giving the correct answers to some questions on the origin of the earth: "I know that these are the answers you want, but I don't believe what I have written."

So far as the school system is concerned, the task is completed. The pupil's success is attested by her high grade. The teacher's success is evidenced by the large proportion of pupils with high grades. The method is sound, for students are now able to match the answers they remember to the corresponding questions.

But the teacher is troubled. "Have I failed in my teaching? Should I make one more attempt to persuade this exceptionally intelligent pupil to reject her superstitious beliefs? What have I done that I should not have done? What should I have done that I omitted?"

We naturally feel that the science which we teach is important. When we meet resistance or indifference among pupils we try to overcome it through various efforts at what is called "motivation." We grow enthusiastic about the wonderful achievements of science, although the radio and the advertizers generally put over this idea better than we can. What "science" has done to our agriculture, to our housekeeping, to our health, to our transportation, to our communications! How vastly "science" has increased the effectiveness and the productivity of all practical efforts! Many boys are interested; and some girls. But many girls and some boys tell us blandly, "I don't see why I should take that stuff. I'm not going to be a doctor or a chemist or an engineer or a farmer." Or they say, "We don't have to know all that to be able to drive a car or own a refrigerator or a washing machine. You just buy what you want and all you need to know is which button to push."

With all this resistance and indifference, we nevertheless know that we can get a reasonable proportion of the students to remember correct answers to the extent of 60% — or whatever the passing mark may be. But what is that something beyond the correct answers? It is point of view or attitude,

[1]*DR. GRUENBERG of New York City—retired biology teacher, currently author and editor—is science education's chief philosopher. He thinks deeply but writes simply. The subject of his article was the editor's specific request.*

that we miss? Is it an "open mind?" Or the "experimental method?"

In recent years, both textbooks and syllabi have included these items as things to teach. Of course they are important. But how would you teach the "open mind" to boys and girls who come to high school thoroughly soaked in a set of correct answers that all our teaching simply cannot change? Where would you begin? You cannot start out asking them to open their minds and remove all that they have previously learned on the subject — the origin of life, the nature of diseases, where babies come from. You cannot have, nor do you want, completely empty minds to work upon. Nor can you start out by telling the students that their previous teachers were probably mistaken. Nor can you hint that they were deliberately deceived.

All inexperienced teachers find themselves confused by what appear to be contradictions between the educator's "point of view" and that of the students or their families, and sometimes between a teacher's views and those of the entire community. "We teachers know our stuff, that's why we are here. We feel it our duty to replace false beliefs with sound ones, faulty reasoning with correct methods, modern views for ancient ones. But we also know our places. We cannot run head-on against the opinions of our neighbors, our colleagues, and especially of those who hire and fire." There are two possible solutions, as I see it; and both of them involve compromises. To an enquiring young teacher I would give this advice:

You can follow the directions and rules of the system. Stick close to the syllabus and drill on the answers that are to students recall in the tests and examinations. When a "controversial" question shows its head, you can say, "Some people believe this and some believe the opposite." But suppose a student cares enough to ask, "But which is right?" or even, "Which do you believe?" Your safety then lies in answering the first by saying "This is a controversial question because those who know most about it cannot agree. If anybody knew the correct answer, there would be no controversy. This is a question on which it will be necessary to do a lot of investigating, exploring, experimenting, thinking."

In regard to the second query, you can avoid, as cleverly as you know how, all commitments. You can say, "Since there is so much disagreement, it isn't proper for me to influence your views. I can tell you the facts that are accepted, and each of you can make up his own mind." This compromise, whether you manage it easily or with difficulty, troubles most teachers, since it seems to be a compromise with conscience. You feel that you dare not speak your convictions; that you are restrained by fear — fear of antagonizing people, perhaps fear of your standing in the school or community, or even fear of losing your job. Nobody likes that — nobody likes losing his job and nobody likes pursuing a policy that is determined by fear. It goes contrary to our conscience as students of science, and as Americans.

But I suggested that there is another procedure; that too requires compromise. You can say, as in the other method, "Some believe this and some that" and explain why the question is controversial and why a categorical answer cannot be had. But from there on, there need be no dodging.

First, draw out all the opinions there are in the class. There are likely to be more than two, whether you are talking about "evolution" or the origin of the earth, or the causes of disease. So, here we are, nice, bright American boys and girls, unable to agree any more than the professors. We do not agree: the question is controversial, it is open. It is hard to understand how these otherwise nice and intelligent people can hold such strange notions, isn't it? But we do not accuse one another of stupidity or malice, do we? The next step is to find out the warrant for the belief, with the question, *"How do you know?"* — that the earth started so, or that the evil eye is the cause of jaundice, or that a strawberry-mark is due to the mother's fright during pregnancy?

Give everybody a chance to answer the question, give everybody a chance to tell *how he knows.* Most of the children will not tell how they know: they will tell the authority for their "beliefs" or they will offer some good reasons for "believing" as they do. Mother told me. I read in a book. At my home, we have always known. It stands to reason. I can't imagine any other explanation. It all comes down to this: for some people these questions are not "controversial" at all; they know the answers. The trouble has been started by some smarties who were not satisfied with the old and true answers and thought up something new. Remember Galileo? Remember Pasteur? Remember Darwin? Remember — almost any scientist whose name is worth remembering? Perverse individuals unable to let well enough alone, or just being contrary.

As a student of science, you will not be satisfied either. Perhaps you know too much to be satisfied with the old answers, but not enough to feel confident about the new. That is normal and nothing to be worried about. But it should be made clear that nice people can differ, and that their differences have nothing to do with intelligence or good manners or civic virtues. The differences arise far back in the traditions of the Dutch and the Bohemians and the French and the Scotch and the many other nationalities that have peopled our country. Some of the "beliefs" are fragments of local folklore. Some are bits of ancient theologies, which people have tangled up with "religions." Some are the remains of medieval philosophies that have stuck in one part of the population or another.

It does not help to call these ideas "superstitious beliefs" or "primitive views" or unenlightened theories. They exist — and for a long time and for many people each "belief" or "explanation" has served satisfactorily. They were also for the most part harmless, since most people did not put these "beliefs" to practical tests. Certainly we might all be better off if most people did have modern understandings about the principles of hygiene, for example; but most people have their lives so organized that relatively few get into very serious trouble because they do not "believe" in the germ theory. Very few people in modern times have gotten into practical difficulties because they treated their farms or boat-rides as if the earth were flat. Very few people have had real trouble because they believed about species with Linnaeus rather than Darwin, or because they agreed with Lamarck instead of Weissmann.

If we can agree that varying views

have a legitimate place among intelligent people, we can ask the next important question: *How can we tell?* Obviously not by taking a vote. Nor by asking anybody who always believed what his great grandfather believed. Nor by asking the person with the new upsetting and perhaps confusing ideas. If those who have ancient beliefs are prejudiced and have closed minds, the man with a new idea may be equally biased, equally resistant to what others think. An idea is not validated by its antiquity — nor by its novelty. It is futile to turn to authorities then.

Well, how would you convince me that your view is right? Merely by arguing? By repeating and repeating, by shouting at me, by knocking me down? Then again, assuming for the sake of argument that one of us is right and the other wrong, what would it take to convince you that you are wrong? What must be shown on which there can be no doubt? Behind arguments, with the best of logic, and behind conviction, with the best of faith, lies the material universe out of which we have to dig the significant facts. Not what everybody has always known, not what you find in a book, not what you wish were so. *Facts* must be found, facts on which we can agree because we can all see for ourselves, and facts which are pertinent to the issue.

This is the point on which all the lines of discussion must sooner or later converge. *What are the most reliable methods we have for resolving divergent ways of explaining or interpreting human experience?* What are some of the different methods people have used in the past? What are the methods by which we meet our own uncertainties in practical affairs? How did America solve the problems which the pioneers had to meet under new conditions and without standard practice? How do we find out whether that gray stone or that pink stone is harder? In addition to arguments, in addition to hunches, in addition to what grandmother always said, in addition to what the label on the package says, how in the name of common sense can we make sure?

Of course, if you wait for a disturbing controversial question to arise, you will be quite unprepared with all this. But to track back a little, this is what it amounts to. We do not agree because, as the question is put, nobody really *knows*. And you do not have to believe what I believe. Perhaps I could convince you if I tried; but I am not going to try. I want you to consider only how it comes about that decent and intelligent people *do* differ. The germs, for example. I can show them to you in the microscope. I can show you that they do grow and multiply. I can show you that there are many kinds, that they are killed by heat and by various chemicals, that they thrive and multiply better under some conditions than under others. None of this, however, *proves* their connection with sickness.

But consider this: hundreds of students, working independently, have separated out a particular kind of "germ" from every diptheria patient (for example) that they examined. They have "cultivated" these derived germs generation after generation, like what you see in these plates or tubes. And they have then brought on the marks of the disease in horses or guinea pigs or goats by using some of these cultured germs. In other words, nobody has been able to find a case of

diphtheria without the presence of these germs in the body; and wherever the germs get into a possible "host" the signs of the disease appear. I cannot carry these experiments on here, for even if I did not "believe" the theory, I would not take a chance of getting any of you sick. But that is all there is to the argument. If the terms and conditions presented make sense, the conclusion is unavoidable. If there were another theory that works just as consistently as this, we should then be in doubt. We should have to devise new experiments to check *on both theories.* At the moment, there is no rival theory, so there is no controversy.

This does not mean that all diseases are caused by "germs." You do not disprove the theory by showing that rickets and goitre and a dozen other diseases may be present without the consistent presence of some particular kind of germ. The argument and the evidence are positive. They are practical, since they arise out what we do in a situation; and they are practical also because by *acting* on this supposition we get certain kinds of results — in this case, results related to improving health.

By following this method you are making a compromise — with your convictions. You are virtually admitting that *you may be mistaken.* That is difficult for most people. But unless you are ready to do this — not reluctantly, but willingly — then you cannot ask your students to concede the possibility that *they* may be mistaken. And unless you can get them to concede this much, you will never teach them science. For among its other roots, science has its beginnings in just this: somebody acknowledges that he does *not* know. When we recognize that we do not know, we are in a position to consider, "How can we tell?" — that is, in a position to undertake the study of science.

"Through such contacts (science workshops) we can come to know one another better, learn to work more effectively together, develop a professional unity and clarity of group purpose which has been too often lacking among science teachers in many regions of the United States."

—R. Will Burnett in *The Science Teacher.*

"Barren science classrooms are still too prevalent in this country."—DOWLING.

How *to* Enrich *the* Future Science Program

By THOMAS I. DOWLING[1]

A "GOOD" teacher has always enriched the experiences of students. This is one of the outstanding characteristics of a good teacher. Students, also, have a part to play in the enrichment of a program if they are to gain the greatest value from instruction. The best program of science instruction is to be found where the teacher and the student help each other in sharing experiences. Enrichment is a matter of meaningful experience.

All of the sciences are particularly rich in experiences for boys and girls of all age levels. These experiences are valuable to the learner in meeting the problems which confront his every day living. Our complex civilization makes greater demands upon the individual if he is to be an asset rather than a liability.

Barren science classrooms are still too prevalent in this country. Experiencing in science requires that materials be avilable. In many schools, the only materials have been largely textbooks, a meager library, chairs, desks, tables and other conventional classroom equipment. This type of material may have been sufficient (?) at a time when electrons, vitamins, plastics, alloys, rayon, penicillin, immunization and a host of other things were unknown. Today, the reader of the average daily newspaper requires considerable science experience if the articles which quote science information are to be meaningful to the reader.

In this article, we are concerned with how to enrich the science program of the future. It consists largely of a greater utilization of the many ways that teachers in the past have endeavored to make more meaningful the science experiences.

The Science Museum

The future will see a growth in the school science museum. At present, the science museum may consist of a corner of the classroom which has been set aside as a museum, a place where students assemble exhibits which illustrate the science principles they are studying. In some schools, a special room has been given over to the science museum. Student curators operate it as a part of their science program.

The school science museum is, in some ways, quite different from a regular museum, in that the students may handle most of the exhibits, thereby

[1] *MR. DOWLING has made the Science Department of the Albert Leonard High School, New Rochelle, N. Y., a most stimulating factor in an alert community. If a father of the neighborhood misses a tool or gadget, his first suspicion is that the son or daughter has carried it to science class for a demonstration.*

gaining further information than would be provided by only looking. Many of the exhibits are of a workable type, where the student pushes a button, turns a wheel or in some other way lights an exhibit or sets it in motion.

Living things are not to be overlooked in the science museum. Plant and animal life of various types and kinds provide experiences in a great variety.

The science museum provides an opportunity for the learner to bring together his ideas and to explain relationships through the use of materials. Some teachers are of the opinion that the school science museum is of as much value as a laboratory in the educative process.

Motion Pictures

This war has shown some interesting experiences in mass instruction. The armed forces confronted with men and women of varying educational backgrounds has used the motion picture to a great degree in presenting specific information to its members. School people marvel at the results which have been obtained.

The enriched program of science will certainly rely upon motion pictures in providing experiences for boys and girls of our school. Through time-lapse photography, slow motion, cartoons and numerous other techniques certain experiences may be shown which would be impossible for the learner to perform or which the time factor prevented.

Science motion pictures have shown a great improvement since they were first introduced.

Science films may now be rented from several depositories located in every state of the union. The fees are quite moderate. In some school systems films are purchased and rented out to neighbor schools or exchanged with other schools.

The science classes, in some schools, are now producing their own science films. This movement is surely to grow as film and cameras become plentiful. What an excellent project this becomes when a science class undertakes to produce a film upon any science topic.

Science Realia

The paucity of materials in many science classrooms is quite appalling when one thinks of the great number of materials present in every environment of every community and may be had at no cost to the science budget. A partial list is given to suggest possibilities:

cut open dry cell
cut apart water faucet
section of telephone cable
rudder from a small boat
telephone receiver
old radio tubes
gears from a wrecked automobile
types of plastic from old toothbrush handles and bottle caps
discarded flashlight
empty gun shell
sling shot
motion picture film showing sound track
local rocks and minerals
samples of local soil
life history of common insects
section of a log
bird nests
extracted teeth
portion of skeletons of animals
kerosene lamp
burned out street lamp

Booklets, Pamphlets, Charts

Students seldom find enough information or illustrations upon a science problem in a textbook. An enriched program provides a wealth of supplementary materials in the form of booklets, pamphlets, charts for additional study. A considerable quantity of reliable science information and illustrative materials are now being distributed by various manufacturing and research organizations[2] in this country. A greater portion of it is free upon request of the teacher. A penny postal usually suffices to bring this material into the classroom.

During the past few years there has been a tremendous gain in the number of educational publications of commercial enterprizes. The trend of these publications have been towards better organization and presentation of materials.

A good science library is also essential to an enriched program of teaching. For many years Dr. Hanor A. Webb[3] has performed a very valuable service to the science teachers by publishing each year an annotated list of science books for the high school library. This list should be in the hands of every high school librarian.

Each week during the school year, there is published *Current Science and Aviation*[4] which furnishes to the boys and girls the recent happenings in all of the sciences. This publication rates very high with teachers and students looking for current science information.

Out-of-School Laboratory

The future science program will find itself more closely tied to the community. This will be done through using the community as out-of-school laboratory. Excursions and trips will be more frequent and useful than in past years. A successful school program cannot confine its program entirely to the walls of the classroom. The applications of science are to be found in the numerous activities of the citizens of the community.

Techniques for using the community have only partially been exploited. The proper use of excursions and trips involve techniques that many teachers have not had the opportunity of using. One very helpful publication[5] has been prepared in this field.

Experiments

Experiment and observation have always been an important part of science instruction. Has the present courses of science promoted and encouraged this aspect of experiencing? There has been some evidence which supports the idea that we are not making the most of this in our science program. Certainly the mere following of stereotyped experiments to which students frequently know the answers is dubious. In general, the experimental part of our present courses seem to lack the challenge that appeals to students. Most of the so-called experiments are really repetitions of demonstrations that the students have seen or are described in their textbooks.

2 Write for catalog of General Electric Service for Teachers, General Electric Company, Publicity Department, Schenectady, N. Y. Write for illustrated catalog of free and low cost teaching aids from Westinghouse Electric and Manufacturing Company, School Service, 306 Fourth Avenue, Pittsburgh, Pa. Write to General Motors Corporation, Public Relations Department, 3044 West Grand Blvd., Detroit (2), Mich. for teaching aids and charts.

3 Dr. Hanor A. Webb, George Peabody College for Teachers, Nashville, Tenn., is able to furnish this list at a nominal charge.

4 Published by American Education Press, Inc., 400 S. Front Street, Columbus 15, Ohio.

5 Pitluca, George E., "Science Excursions Into the Community." Bureau of Publications, Teachers College, Columbia University, New York, N. Y.

The future program should provide an opportunity for the return of the experiement in a true meaning of the word. The organization of science about real problems vital to students commands the use of experiment and accurate observations. The real heart of science is the experiment and if this aspect is removed or ignored, there is not much left that may be called science.

Science Clubs

Science clubs, whether a regular part of the curriculum or as extracurricular activities, has in the past constituted, in a sense, a part of the enrichment of science instruction.

The Science Clubs of America, sponsored by Science Service, has been of great assistance in promoting an excellent program in the schools of the nation. Every teacher will profit from the materials sent out by this organization.[6]

Science clubs to be of the greatest value should reach great numbers of the students.

The best program of science is going to provide the students of our school with more and more opportunities of "doing thing." If we accept the democratic idea, it is the individual that is important, then we shall see more effort exerted in providing experiences that the individual will find useful in growing to his full stature. Certainly, the sciences of the future with an enriched program will have a fundamental part to play in this development.

6 Science Clubs of America, Science Service, 1719 N Street N. W., Washington, D. C. The following pamphlet are free. How to Organize and Activate Your Science Club. Books for Science Clubs. 1000 Projects for Science Clubs. Sponsor Guide. Free and Low Cost Materials for Science Clubs. Science Club Co-Projects.

"Teachers must become militant about conservation. The conservation battle will be won or lost in the schoolrooms of America. We are happy to report that a preliminary survey shows that the science teachers are more keenly alert to this problem than any other group of teachers. Even as early as 1940 the report *Science Instruction and America's Problems* issued by the Department of Science Instruction of the National Education Association devoted more than twenty percent of its space to conservation information."

—Ollie E. Fink in *The Science Teacher.*

"The youth of today, in his home and in his daily living, is constantly alert to the latest developments of scientific and technological research."—MACLEAN.

Industry's Obligation *to the* Science Teacher

By CHARLES W. MACLEAN *and* G. EDWARD PENDRAY[1]

SCIENCE education to be truly sound must parallel the progress of the race in science knowledge. But man's knowledge of science is increasing at an extraordinary pace and is placing an ever-increasing burden upon the science teacher .

Until the first World War, most of the scientific work of the country was being done in private laboratories; in the laboratories of colleges and research institutions. But the war brought demands which these laboratories were unable to meet. Shortages of necessary materials required the development of synthetic or substitute materials; the need for speed in production required research into engineering methods and manufacturing processes; development and improvement of war weapons required new research techniques, in some cases into entirely new fields. The existing agencies were insufficient to cope with this heavy load, with the result that industrial laboratories were developed to meet the need. By 1918 there were three times as many research laboratories and research workers as there had been before the war.

However, when World War I ended, industrial laboratories, instead of decreasing their activities, increased them. Many of the ideas and developments of science and engineering were found to have peacetime applications, and eventually, through industrial research, they contributed much to the economy of the Twenties. The vast expansion of radio boardcasting during those years, for example, owed part of its impetus to the development of compact and rugged field sets during the war and to the wartime explorations into new materials, among which were plastics suitable for inexpensive radio receiver cabinets. The tremendous growth of the automobile industry during the Twenties was made possible during the war years, when industry, speeding up production, streamlined manufacturing methods

[1]*PROF. MacLEAN is Manager of School Service, Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa. He brings to this Service a wide experience as teacher, principal, and a superintendent of schools.*

DR. PENDRAY, after becoming established as a science writer, embarked some years ago upon a series of projects notable for their originality. He made headlines (and perhaps history) by his experiments as President of the American Rocket Society. His fertile mind conceived the science demonstrations by high school students at the New York World's Fairs; the "Time Capsule" that was buried on the Fair site September 23, 1938, not to be opened for 5,000 years; the Annual Science Talent Search among high school seniors sponsored by Science Clubs of America, with Westinghouse Scholarship Awards to the most oustanding. Dr. Pendray is Assistant to the President, Westinghouse Electric and Manufacturing Company.

and improved techniques for forming sheet metal. Aviation began to grow up during World War I, and research done during the war was continued and enlarged in postwar years to pave the way for vast developments in air transportation. The scientific laboratory had proved itself not only an invaluable war weapon but also a powerful force in shaping peacetime frontiers. In 1920, 297 companies had research laboratories in this country, employing about 7400 research men of various kinds. By 1927, 1,000 companies had laboratories, employing 19,000 scientists. The industrial applications of science had begun to become more and more important.

By 1931, 1520 companies had laboratories, employing 33,000 men and in 1940, 2350 companies had laboratories, employing 70,000 men. The stimulus of World War II, like World War I, will undoubtedly continue to increase this upward trend.

This extraordinarily rapid progress in science and engineering during a comparatively few years has created a difficult problem for the high school science teacher, as well as the college teacher. The high school science teacher must give the average student a working knowledge of some of the specific ways in which the facts, principles, and laws of his environment are related to and used in the world's work, in order that he may more fully appreciate the vital place of science in the community and its bearing upon national progress. In doing this, he must inspire his gifted students to take further study of advanced science in order to enable them successfully to undertake science as a career. In these gifted young people, he must develop the fundamental knowledges and skills which will enable them to continue to study in college and beyond, to contribute to science to the fullest extent of their ability.

The accomplishment of these objectives by the science teacher is not easy. In most cases his own scientific education has been along general lines with perhaps some specialization in biology, physics, or chemistry. However, under the usual teaching situations, he must teach all of these along with general science, which covers even a wider scope. His textbooks in many cases are several years old and tend to use examples which are not up-to-date enough to interest the modern youth, yet the teacher, because of his specialized background has difficulty in giving illustrations from his own training. The youth of today, in his home and in his daily living, is constantly alert to the latest developments of scientific and technological research. In order to retain his interest, the illustrations used by the science teacher must be up-to-the-minute. The youth of today is interested in such things as radar, penicillin, the automatic pilot, plastics, the rocket plane; he wants to know more about them in his science courses. The teacher on the other hand probably received his scientific training years before these things were ever developed.

The instructor tries his best to keep up with modern developments in science, but many factors work against him. In most schools his teaching load has been increased. He has probably been given supervision over certain extracurricular activities, such as the Science Club, or the Noon Hour Program. He has been heavily loaded with community activities — Civilian Defense, Volunteer Firemen, Boy

Scouts, and the like. His ability to supply pupils with scientific reference books has been hampered by the usual, restricted school budget which must now meet increased costs for every item in the educational program.

Since industry has such an important stake in the continuing development of new blood in its scientific ranks, and depends upon the schools to provide the basic training and the spark which will create the desire in youth to follow science as a career, it has a definite obligation to the science teacher to see that he and his students are kept informed of the latest achievements in scientific and industrial research.

For industrial research needs youth. Youth has two outstanding resources which are absolutely necessary to scientific progress — originality and creativeness. The originality and creativeness of youth, combined with the experience and cold calculation of age, result in a well-balanced industrial research laboratory. Too often in the past youth has been led to believe that success in science has been achieved only by men of middle years or older. Yet Patent Office record show the following definite statistics: the invention of aniline dyes by Sir William Perkin at 18; the steam engine governor by William Siemens at 20; electroplating by Bessemer at 21; the air-brake by Westinghouse at 23, the stock ticker by Edison at 24; the sewing machine by Howe at 26; the cotton gin by Whitney at 27; the steam engine by Watt at 29; the telephone by Bell at 29, and the linotype by Mergenthaler at 30. When one realizes the amount of original work necessary before any invention is patented, this evidence of the contributions of youth to scientific progress is even more pronounced.

If, then, it is the obligation of industry to aid the science teacher, how specifically, may it do so without creating the impression that it is trying to reorganize the science curriculum?

During the past few years, the Westinghouse Company has attempted to do its share to supply this need by the creation of several types of science teaching aids for use in high school science classes. It has created pictorial bulletins on the latest developments in scientific research and industrial engineering. It has developed wall charts, explaining the scientific principles involved in familiar electrical devices, such as the incandescent lamp, the automatic toaster, the vacuum cleaner, the electric refrigerator, and the fluorescent lamp. These charts are kept constantly revised as the products themselves are improved.

Sound motion pictures on electricity, electronics, radio, and other scientific and technological subjects, distributed through the Company's School Service Department, were last year viewed and studied by more than 2,500,000 high school students.

Little Science Series booklets — short, complete accounts on different fields of science — have been prepared to help teachers and student supplement the textbook with -up-to-date material and information.

For school systems having their own broadcasting stations or cooperative commercial stations nearby, a weekly radio program called, "Adventures in Research," is made available. In addition, recordings of this program have been placed with the United

States Department of Education for free loan to school systems having their own play-back equipment.

Finally, as further inducement to outstanding boys and girls to take up science as a career, 61 scholarships totaling $40,300 each year are awarded high school seniors especially gifted in science or engineering.

This is merely an example of an industry's effort to share its knowledge and experience with the schools of the nation. Other industries also are seeking to do their part.

World War II has been truly called a scientists war, and its impetus to research and industrial development has been even more pronounced than that of World War I. Almost universally, research departments have packed approximately 15 years of development work into the three years that the United States has been at war. Postwar applications of these developments are almost limitless and will provide opportunities for well trained science students in every field. It is the duty of the science teacher to keep abreast of these developments so as to retain the vitality of his teaching. It is the obligation of industry to do everything possible to assist him.

"Science to the young person can be as dry and dusty as the tomb of a Pharoah, or it can be as alive and fresh as a sunrise on a June morning. One way to make science and scientific information live in the students' minds is to relate it to the land, the waters, the permanent vegetation, the creatures — in short, the land in which he lives."

—E. R. Martel in *The Science Teacher.*

"Even as our future national defense will require more scientific workers than ever before, so the need for training capable science teachers will be greater."—QUILL.

Some Problems Affecting Chemical Education

By LAURENCE L. QUILL[1]

WHEN those of us engaged in chemical education ponder on our problems, we think about the rehabilitation of teaching staffs; teaching loads and the increasing tendency to place college and university instructors on a twelve month's basis; the training of professional chemists and of chemical technicians; the complexities of program building because of the impinging of "liberal education" programs on established professional curricula; and of other topics of both major and minor importance. Anyone of these topics is worthy for a long dissertation and considerable debate. None of them can be given a complete positive answer. This series of rambling thoughts, therefore, will not attempt to give solutions to these problems but will try to emphasize and outline a few factors concerning them.

Rehabilitation of the Teaching Staffs

A major task in departments of chemistry at the present time is the securing of suitably trained personnel. The supply of doctorates, fresh from their university studies, is inadequate to meet the demands of either the teaching or industrial fields. Most of the young men who have been successful in completing their advanced studies, despite the vagaries of the Selective Service System, are lured toward industry by the apparent greater opportunity to contribute to the war program and by the relatively larger industrial salaries. Many college administrators believed, in early 1944, that it would not be difficult to recruit younger doctorates from the chemical industries when the war was over "because the young men would desire to get back into college teaching." Another year has passed, the war is not over. The young doctorates in industry are more mature; very probably their salaries have been increased in that year. The supply of young doctorates from the graduate schools has not increased. The outlook for developing young men as teachers of chemistry in the college field is not so promising as in early 1944. Selective Service rules permit very few capable young men to graduate from college; consequently, they never get to graduate school. To depend upon returning veterans as potential graduate students for a source of chemists is to build up false hopes.

[1] *DR. QUILL'S responsibilities as Supervisor of General Chemistry, Ohio State University, as Head of the Department of Chemistry, University of Kentucky, and now Head of the Department of Chemistry, Michigan State College, East Lansing, Mich., make authoritative his discussion of training for chemical industry, research, and teaching.*

Indications are that the breakdown in the development of trained chemists for the teaching profession (and industry) will persist until about 1950. That outlook is not optimistic nor cheering. In the meantime, colleges and universities are having their problems. Enrollments are increasing; demands on the staffs are heavy; teaching, like "the show," must go on.

What are a few of the points which should be considered with respect to the rehabilitation of the teaching staffs of science departments? Naturally, veterans, who were formerly instructors, should receive first consideration in respect to expanding the teaching groups. Following those changes, great caution should be employed in the selection of new staff members. Ill-considered appointments during the expanding enrollment stage may well prove to be a source of embarrassment and trouble to the teaching staff and to the administration in future years. Many colleges and universities have been "saddled" with instructors who were employed in the academic inflation following the last war and who developed into problem cases rather than high quality teachers. It could easily happen again, if prudence were not observed, and if the need for a teacher of any sort overbalanced the long-term aim to build a strong department. Such occurrences could be kept to a minimum if the custom of probationary periods of three or four years duration for beginning instructors were strictly adhered to or if an "apprentice-plan" for full-time instructors were devised.

An important question to be given strong consideration in the rehabilitation of the teaching staff is linked directly with our scientific development. "The efficiency of our war production is dependent upon the state of development of our science and technology (1)." The continued greatness of our nation's activities will also be dependent on the development of our science and technology. The strangulation of our future scientific development must not occur. As Rakestraw[2] has pointed out, "we based our system of military procurement upon a principle of Selective Service, but we have largely abandoned this principle, it appears. We are making it more and more difficult for young men to contribute their particular talents to the national welfare. We must beware of making the same mistakes in sober, peace-time military training that we are now making in the excitement of war."

Even as our future national defense will require more scientific workers than ever before[3] so the need for training capable science teachers will be greater. Our standards of education must not be lowered to meet the requirements of compulsory military training. Both are very essential for the nation's welfare. The principle of Selective Service must be applied to the education of those who are planning on entering the scientific professions. If the principle is applied so that capable young men are carried through to the doctorate degree, there will be the necessary supply of high quality instructors, of professional

2 Rakestraw, Norris, Jour. Chem. Educ. 22, 1 (1944.)

3 The present article was already in manuscript when the author and editor heard the broadcast, "Science and Our Nation's Future," by Arthur H. Compton of the University of Chicago, January 14, 1945. This address is published in Chemical and Engineering News, 23, insert (Jan. 25, 1945.) "We have gambled on a short war," says Dr. Compton, "but if the war should continue . . . our present policy of no advanced scientific and technical training will spell national disaster."

scientists, and of other experts. The chemical profession, as well as others, must be aware of this problem when the laws for military training are formulated and act to provide a continuance of professional education for the capable young men[4].

Teaching Loads and the Twelve Month's Schedules

Related to the problem of rehabilitation of the teaching is the problem of teaching loads and salaries. The competition between the chemical industries and institutions of higher learning for well trained professional chemists, with the related fact that industrial salaries are higher, is an oft-debated question. In the last few years, there has been extensive discussion about "subsidizing" or improving salary scales of capable chemistry teachers in order to keep them in the educational field. Chemical industry has been keenly aware of this problem. Of recent times, some colleges and universities have attempted to partially correct the situation. Most of these schools have been paying the instructor on either a nine or ten month's basis. If he taught summer school, he was paid extra. If he so desired, he might locate a summer position to earn extra money. Many of these schools have very recently "increased the salaries" by placing all of the instructional staff on a twelve month's basis. The details of the new scheme vary from school to school so that a variety of problems presented themselves. In some instances, minor dissatisfaction arose because the instructor received less on the twelve month's basis than he formerly earned on the old basis plus the extra summer school stipend. In other schools, it is required that the instructor must devote at least half time to instruction during the summer since he receives pay for that period. Other colleges ask the instructor to utilize that extra time to catch up on his research and his reading for teaching.

Regardless of the many minor problems arising from the tendency to pay on a twelve month's basis, it is desired in this discussion to advise caution with respect to one item. It has become very evident to many of us who have been in charge of the accelerated and armed forces programs that the instructional staff cannot teach year in and year out on a heavy teaching schedule without a subsequent decrease in efficiency and character of teaching, and the killing of interest in research and in the necessary browsing for good teaching. Therefore, the prudent administration and the foresighted instructor should guard against a continuance of too heavy a schedule for too long a time. Heavy teaching loads are accepted readily as a wartime responsibility; heavy loads as a permanent schedule lead to *stagnated instruction.*

Professional Chemist and Chemical Technician

The term "chemist" is greatly misunderstood and misinterpreted. The "all-out" war has accentuated certain difficulties in interpreting the meaning. The tremendous demand for technicians who can make chemical analyses or read control instruments under supervision has led to the listing of many employees as chemists of one classification or another. Junior chemists, laboratory assistants, chem-

4 Representatives of the American Association of Colleges, in a recent meeting at Chicago, discussed plans for training outstanding young men for specific positions as college teachers.

ical technicians, and the like are a few of the designations applied. Many persons with only a high school education have been employed to do routine operations in the chemical laboratories or plants. A surprisingly large number of these individuals consider themselves chemists because after all, "they are doing chemical work." Various ramifications of the problems have arisen. Are not the labor unions attempting to organize these people? Hasn't it been proposed to license chemists under various state laws? And hasn't the education of capable young persons desiring to become professional chemists been entirely disrupted because the present Selective Service System does not recognize the need of training chemists, physicists or other specialists to learn the "know how" of these important fields of learning?

The professional societies such as the American Chemical Society and the American Institute of Chemists are taking the lead in defining the difference between a professional "chemist" and a "chemical technician" and in setting up standards of training and education for the groups. Unions of technical employees have been organized to assist them in protecting their rights in these troubled times. Nevertheless, the educational institutions must be interested in the problem. Since professional chemists and chemical technicians are essential to the operation of chemical and closely related industries, colleges and universities must decide whether they want to train both the technicians (or "pairs of hands") and the professional chemists, or whether they shall encourage large high schools and vocational schools to supervise the problem of technician training, thus leaving only the professional program in the college field. Departments of chemistry must determine whether the training of technicians as well as of professional chemists shall be included in their post war curricula. Departments of chemistry and their respective colleges must likewise consider whether now is the time to expand the curriculum for the professional to a five year program.

Liberal Education and the Chemistry Curriculum

Since the wartime programs of most colleges and universities are temporarily stabilized, faculties are devoting considerable thought to the building of "liberal education" curricula. The concept of a "liberal education" has so many ramifications that an attempt to define the term or to argue the point will not be discussed. An effort will be made to comment on a few of the factors which concern the chemist and liberal education. The discussion may be taken up from the two points of view: First, the chemist and the liberal education program; second, liberal education and the chemistry program.

Chemists, in general, are not opposed to the idea of a broad or liberal education. Those of us who serve as advisors to prospective professional chemists are convinced that the young advisees should be made very keenly aware of the social and economic conditions of the world, and how these conditions will affect them and their profession. Likewise, we recognize the values gained from foreign languages, public speaking, advanced English composition, economics, and the like, as adjunct studies in the broad

training of chemists. We want them educated and trained to stand the competition of the business world into which they enter when they leave college. We want them prepared to appreciate and enjoy life. However, we advisors to prospective chemists are not in favor of adding diluted "liberal courses" which give only vague or superficial ideas of a subject or which will degrade into the "snap" course type. We are also not in favor of overloading the professional curricula with courses in the humanistics to the point where the professional courses are in the minority.

With respect to liberal education programs, the chemistry instructor has certain obligations. He must give whole-hearted support to the program, if it is adopted, to guarantee that the chemistry part of the program shall be thorough and shall include those fundamentals which are essential to the broad education of the student. He must be alert to the problem that the chemical part of the program shall be from the "science of chemistry" and not from the "art of chemistry." Many administrators and educators have unconsciously developed the idea that the type of chemistry which should be taught in the liberal education programs should be closely akin to the popular lectures they have heard from the lecture platform and on the radio. They have seen the "glamor" of chemistry, but they have not gained the sincere appreciation of chemistry which results from a study of a few simple fundamentals and their underlying philosophy. Unfortunately, many of the people who desire to have a chemistry course of the liberal type, devoid of the concepts which illustrate the science, recall incidents of the days when they were "required" to take chemistry with its apparently "abhorred" formulas, equations and problems. Unfortunately, also, too often the chemistry teacher unintentionally added to the dislike of chemistry by teaching all of the students as though they were going to become professional chemists. Consequently, we have arrived at a period when problems arise due to the over advertising of the glories of chemistry on the one hand and the lack of appreciation of what constitutes the "science of chemistry" on the other. Too many people think of chemistry as magic; they have no realization of the problems and expense in time, money, manpower and thought to develop products such as nylon, leucite, anti-malarials and the like. Hence, the chemist has a real obligation in the liberal education program to present a true picture of the "science of chemistry" and its cultural value.

Whether the chemistry is taught in a "fused" physical science course or as a separate chemistry course, a careful selection of a few of the important fundamental concepts should be made; the philosophy underlying the concepts must be included. That chemistry is quantitative; that its formulas and equations have a significance; that there is an orderliness to the science; these and a few other facts can be taught without "petrifying the students with fear." All of the laws of chemistry should not be crowded into a limited course of study. The chemistry teacher must be a salesman of the philosophy of the science to those who are interested in broadening their educational experience. He must also guard against the

chemistry in the liberal education program from becoming too diluted.

The idea of a liberal education for chemistry was recognized almost ten years ago by the American Chemical Society Committee on the Training of Professional Chemists. One of the *minimum* requirements is:

> "*Humanities.* At least the equivalent of one-half a student's residence time for one year must be devoted to the study of humanities, which may be interpreted as nonspecialized courses other than in the physical sciences and mathematics. This is exclusive of the required English and languages."

One year of English and a reading knowledge of German are required. Most schools consider two years of language necessary to obtain a reading knowledge. The English and foreign language requirement thus amounts to better than one-half year of study. The combined humanities English and language requirements means that more than one year of the student's time is devoted to other than the physical sciences and mathematics. This fact is not fully appreciated by most of the critics of the chemistry program. They see only the physics, mathematics and chemistry courses which are outlined. This relationship that a very *minimum* of one-fourth of the student's program must be outside of the physical sciences and mathematics is mentioned merely to point out that the chemistry student must study courses other than his major. The chemistry program also provides for a firm foundation in fundamentals by the requirement of mathematics and physics. In many colleges, public speaking, engineering drawing, advanced report writing, etc., are included in addition to the minimum requirements outlined by the American Chemical Society.

Two important problems in connection with the combination of the liberal and the chemistry programs are the length of the program, and the adjustments needed due to "fused" physical science programs as part of a basic college program. We advisors to chemistry majors realize the difficulties of outlining a student's program so he can complete all of it in four academic years. As a matter of fact, it takes an exceptional student to complete the course of study in that time. Unless the scheduling of the individual offerings is almost perfect, graduation in four years is impossible. Since most of the students are desirous of studying certain other courses than the minimum required, and since the present four year's program is full, it might be well to consider the adoption of a five-year chemistry curriculum for the post war period. Many engineering colleges are now reorganizing their programs on a five-year basis. A study of the records in any registrar's office will show, for the engineering curricula, that a higher percentage of the students do not finish than do finish in the four academic years. Also, the summer programs of the pre-war period (inspection tours, surveying camps, summer work experience, etc.) were in addition to the four year's residence. A study of chemistry programs will likewise show that a majority of the students are enrolled for more than an even four academic years. The five-year curriculum in chemistry, like the equivalent five-year one of engineering, will have many advantages. It will permit a flexibility of scheduling not possible

under a rigid four-year schedule. Students who are desirous of taking courses in addition to the minimum requirements will be in a better position to do so. Many chemistry students enjoy playing in college orchestras or bands, which they cannot do in the usual four-year program because of the lack of time. The five-year curriculum will allow the student to study two foreign languages as well as to include other "humanities" in the program. Under the usual four-year schedule, if the student chooses to take two languages, he probably must forego economics, history and the like; if he chooses the latter, time does not permit a second language. The five-year curriculum will permit a more leisurely rather than driving pace as is needed to complete the usual four-year schedule.

Naturally, the extension to a five-year program raises the question as to what degree should be given. Since the title "bachelor" for the first degree is traditional, it would seem almost impossible to eliminate that term. The adherents of general programs would want the bachelor's degree maintained. On the other hand, the distinction could be made between a simple Bachelor of Arts or of Science degree and "professional" degrees such as Bachelor of Science in Chemistry, Bachelor of Science in Physics, Bachelor of Arts in History, etc. An educational program should then be instituted to inform interested people of the distinctions between the two types of programs.

The second problem about liberal education and chemistry programs pertains to adjustments which arise when students are required to register for "basic college" programs in their first years of study. This problem, in principle, applies not only to the chemistry curriculum but to programs in engineering, home economics, medical technology, and the like. Let us apply the question to a chemistry curriculum. In this program, the arrangement of advanced work is based on a series of prerequisites in mathematics, chemistry, physics and German. If the student who knows he wants to major in chemistry is required to register in "basic college" courses his first years, he will be unable to plan all his program so that the necessary mathematics and chemistry fundamental to later work can be completed by the end of his second year of work. For example, a student has one year of physical science sequence (which includes chemistry, physics, geology, astronomy). He has credits to be a sophomore; he wants to major in chemistry. Obviously, he does not have sufficient chemistry to admit him to quantitative analysis. He probably is not prepared for calculus. The student and his advisor have the problem of deciding where he shall take up his regular program. He has had some chemistry but how does it fit into a picture? Should the student start with the second semester or second quarter course in general chemistry? Should he start from the beginning? Will it be necessary to devise an entirely new sequence of elementary courses to get the student's program organized so he can build toward the advanced chemistry courses? Will the student who is interested in chemistry be assigned to an advisor early in his educational career so that the two of them can get the entire curriculum planned as soon as possible? First thought in answer to this question

would be that the student will need some type of an elementary chemistry course following the physical science sequence in order to provide him with a proper background for future study. The same argument holds for the home economics or medical technology student. She, too, must have an adequate background of chemistry. The physical science course may delay completion of her program as well. Naturally, how difficult will be the correlation between the physical science and professional programs will be dependent upon how rigidly the combined physical science courses are adhered to or how flexible the scheme is arranged. If at all possible, the *good* student should be given an opportunity to plan his major work with his major advisor as early as possible. In return, the advisor should cooperate in developing the student's program to include those courses which give both breadth and depth. It should also be pointed out that a certain flexibility in a program is essential. A "liberal education" scheme which requires that every student register for identical programs, that regiments every student through the same groove, defeats the purpose for which the program was devised.

Since the concept of a liberal education program is becoming more widely accepted, and since most of the plans require the courses to be taken in the first two years, it appears that it may be necessary to lengthen the curriculum for the professional chemist to five years as already suggested. An alternative would be to permit majors in professional curricula to register for the liberalizing courses in their upper division period. After all, there are many arguments that such courses are most valuable in the junior and senior years to the person who knows what he is going to do. The crux of the matter is that it is impossible to correlate into one program (a) broad and intensive curricula for the *good* students who have chosen a profession for their goal, and (b) liberal or general curricula for those students who are seeking an added educational experience beyond high school. The latter group is the greater in numbers; it is important that they be given the best of instruction and advice possible. The former group, however, includes our leaders of tomorrow. Let us who are advisors not forget, for a single moment, that we have a genuine obligation to the first group. The earlier we can get them started toward their goal, the better for them and for our nation.

"Again I must say, above all things — especially to young people writing: For the love of God, don't condescend!"

—Charles Dickens

"Obviously, the successful physics teacher must be well prepared in several subjects."—AYERS.

Post-War Instruction *in* Physics

By A. R. AYERS[1]

WHERE scientific industry leads the science teacher should follow. World War I summoned the chemist from his academic seclusion; World War II has called the physicist into the ranks of the active war workers. We have learned from two conflicts that no security is possible unless men of industry, men of science, and men of arms cooperate in a single closely coordinated effort.

The present struggle has been called the "physicists war," and the coming period is designated as an "age of physics," comparable to the "age of chemistry" which followed World War I. This is misleading. The two fields are inseparable and together their discoveries and contributions are invaluable for every phase of science and industry.

Typical advances that the physics teacher of the future must be prepared to explain and perhaps even to demonstrate come in fields of food, clothing, shelter, air-conditioning, communication, transportation, medicine, and a host of other benefits of science to humanity. Physics teachers must know, for example, new methods of processing foodstuffs involving such physical operations as freezing, pressing under control, pressure cooking, de-aeriating, centrifuging, and the like. Their students may ask how and why the design and texture of wearing apparel are influenced more and more by science rather than by appearance and style alone. The construction, ventilation, and heating of modern homes introduces new studies of properties of materials, conditioned air, heat transfer and many other topics which come under the heading of physics. The post-war physics instructor must have knowledge and equipment, for instance, to demonstrate certain kinds of glass which become hot when exposed to infra-red rays, because we may cook our meals in glass dishes by radiation from above with lamps that replace the stove. Students may want to understand the principles involved in glass partitions which consist of polarizing plates, giving light or darkness by sliding one of the plates. Other kinds of selective glass will transmit only certain desired rays for health and the reasons must be shown.

In the future home, heating elements may be enclosed in colored glass panels. Porous glass, used in place of wall plaster, may brighten the rooms. Illuminated mirrors will reflect sun-tan rays. Luminiscent panels,

[1]*DR. AYERS is Head of the Physics Department, George Peabody College for Teachers, Nashville, Tenn. His timely study of aeronautics courses in Southern high schools, and his direction of physics instruction of U. S. Army Air Forces in the College, qualify him to discuss new responsibilities the physics teacher must assume.*

pillars and walls of luminiscent plastics and new type glass will glow when electric tubes turn on the house lights as darkness approaches. Walls of this material may admit the outdoor light.

When the lady of this house pushes a button, micro-waves will immediately make the room comfortably warm. Wartime electronics are largely yet a secret, but the reasonable prediction is that the lady may turn to a single piece of furniture carrying sound broadcasting, television, telephone, phonograph, and facsimilie reproduction, turn on the television in color, and order meats, vegetables and other groceries while viewing the goods in the dealer's store. While taking her morning stroll, she may take along a hand bag with the aid of which she can talk to any friend within miles who has a similar bag.

If the lady gets caught in a shower of rain while she is strolling, she can call her husband over her handbag radio and have him come for her in their new car, of which part of the sides and top will be transparent. These windshields, which will protect from glare, will shed rain and ice without need of a wiper. A small, powerful engine made of light-weight post-war steel will furnish the power to propel the new car.

Almost immediately after the war there will be a trans-Atlantic plane service with many flights daily, making the trip in less than eight hours. Radar will make navigation in the air safer and easier, planes will carry passengers and freight over land and sea, while thousands of persons will be employed in this gigantic aviation industry. The future physics teacher must be prepared to discuss aeronautics, navigation, electronics, radar and the like in order to serve the needs of his students. The future physics laboratory will be a physicist's dream with electronic equipment, wind tunnels and a number of other gadgets.

Men of medicine and surgery need more training in physics. At a recent meeting of surgeons, there was an expression of the need for more people with a knowledge of oxygen tensions, barometric pressures, the gas laws, and technicians skilled in the operation of physical controls. There will be speedy advances in radio-active and X-ray treatments for cancer and other diseases after the war. We started the war with one type of electron misroscope and now we have three. Some of the unsolved causes of diseases may soon be explained.

Physics teachers are finding it difficult to keep up to date on new research results. A great mass of increased knowledge has resulted from the experimental and theoretical investigations of the propogation of electromagnetic waves of various frequencies in the form of ground and sky waves. New methods of generating these waves have been developed, thus making possible commercial application of hitherto unused portions of the frequency spectrum. Crystals are used for such purposes as frequency control, frequency conversion, detection, and rectification. Frequency modulation and new types of directional antennae, such as paraboloidal mirrors and horns, are being used to increase efficiency of transmission and to discriminate strongly against interfering signals. New types of cathode ray tubes have been developed to the point that television on large-scale reproduction is now possible both in black and white and in color. Widespread use

of the dial telephone is a reminder that telephony has become more automatic. Such a list of typical advances could be extended to many pages.

Several new machines are destined to influence greatly our social order. The new cotton picker, for example is a part of the physics teacher's study. His students look to him for an explanation of its principles and workings. He must not be so much a specialist that he will not also explain the social and economic consequences of this invention.

A country boy came to town to see the sights. He climbed tortuous flights of steps to gain a lovely view from a tall building. One day a friend showed him how to operate the elevator and he no longer had to make the gruelling climb by stairs. The friend in our parable is the well trained post-war physics instructor. His student is the country boy. It is the physics teacher's duty to teach the elevator method of living.

It is very likely that a plan, using lectures, motion pictures, radio, and television will be developed through the professional physics societies and extended into the high school and among the laymen of the country to tell people what physics is all about. Post-war physics teachers will be key people in such a program. Already at Stanford University a motion picture entitled "What Physics Is" serves as a guidance instrument to incoming freshman.

It is very important to the post-war physics teacher that further improvement in public understanding of our subject be sought. A great deal is to be done; the doing requires careful and thoughtful planning. As public understanding increases, public relations will improve and more students will feel the need of this special knowledge. Science museums will do much in presenting the principles of physics in elementary form to thousands of people. Examples are the Museum of Science and Industry in Chicago and the Franklin Institute Museum in Philadelphia.

It is essential for those in industry to be educated in regard to physics. A recent advertisement of one of the large manufacturers related to the mass spectrograph. Although this device is undisputedly the development of physicists, engineers were credited with its development and chemists with its application. Such blunders should not happen.

It is clear that the interpretative responsibility must be discharged by physics teachers themselves. The interpretation of physics cannot be left to the historian, educational philosophers and the like. It has already been demonstrated how ineffectively these can meet this challenge. Except for a few individuals, they have missed the mark.

We physics teachers now have an opportunity such as comes to educators once in several hundred years. It is an overwhelming prospect. It necessitates, first, the expansion of our own horizons.

The first step in getting the vision is to properly train ourselves in our science. Then we must fit our subject into the matrix of general education.

The greatest significance of the study of physics lies in the intensely human values which it possesses. The scientific idea had its first development in physics and it can disclose some of the principle clues to the way

men think today. Think what it means in the education of a person to gain the concept that the world is knowable. When physics is mentioned many people think only of the machines and gadgets which make our daily routine different from that of a century ago. The utilitarian aspect is very important, but post-war physics teachers must be fully aware that physics is preeminently qualified and has a tremendous advantage as a subject in general education. It is a pioneer in the most productive intellectual field of modern times. Certainly, physicists have done more to influence the course of World War II than any other group of scientists. Any teacher who has this vision of the prominent part played by physics in the general intellectual field will automatically offer the same vision to his pupils.

In the post-war physics class, it will be necessary to come to grips with physics itself. Its history must be incorporated in the subject. We cannot gain our object by generalizing on the science as a whole, substituting a study of the history of physics, or by making easy courses for special groups. If we let people feel that they have acquired an adequate comprehension of physics merely by reading generalizations, we simply deceive them. It is not surprising that an appreciation of physics requires first-hand study, since the same thing is required for art, music, literature, and other subjects of depth and breadth.

At the turn of the century, over 75 per cent of the seniors in secondary schools took physics. Now approximately 25 per cent take physics. In actual numbers, approximately as many students take physics now as then. The decrease is only relative. It is obvious that a great many of this 25 per cent now taking physics are taking it for general education and not for professional reasons. It is practically certain that larger numbers will pursue physics for general education in the post-war era.

Not because we are concerned with the preservation of physics merely as a vested interest, but because of the contribution that physics has made during the past three thousand years to the current pattern of human thought, it should be given a prominent place in any program of general education, not for the sake of physics but to serve the educational program.

We should not " let down the bars" and put the majority of students in physics classes, but we should differentiate physics courses. In order that students may have opportunity to learn in physics according to their ability, we should have Physics A, Physics B, etc., just as we have English A, English B, etc. It is reasonably certain that far more than 25 percent of the students in high school should receive a foundation in physics in the post-war period.

Since physics teachers take this position, they must accept the responsibilities that go with it. It is generally understood that in high schools many teachers are not adequately trained for the teaching of physics. A large number of them (probably over 60 per cent) have had only the first college course, while many have not had that much study. Securing a physics teacher is often a serious problem in the small high school. In many instances, the chemistry or biology teacher, with whom physics is a minor interest or even a pet hate, is muffing the ball.

More than half of the high schools in our country have five teachers or less. These small high schools cannot afford a teacher full time in either of the physics, chemistry, biology, or mathematics fields. Obviously, the successful physics teacher must be well prepared in several subjects. This can be accomplished through some form of comprehensive science major. At George Peabody College for Teachers, for example, a physics major must have two years of a second science and one year of a third as a minimum. A second year of a third science is recommended.

Our pre-war college and university curricula did not adequately meet the needs for physics teachers. In their emphasis on the training of research scientists, they neglected the needs for competent high school teachers. This situation must be remedied, if the teaching of physics in high schools is to become effective. Physics must be taught by soundly and liberally trained and responsible instructors. Federal aid may be necessary to raise the salaries of these instructors, as it has done for home economics, agriculture, and industrial arts teachers.

The program for the improvement of physics teachers will probably begin with the agencies which make the rules for the award of teachers certificates. Influence will be applied here by such professional organizations as the American Institute of Physics and by various leaders in the field. Wide-awake school administrators, also, will take the lead in this work.

The alert post-war physics teacher will be a member of the national professional physics organizations and be a regular reader of the literature in the field. This will keep him posted on the many, many new marvels that are bound to come with peace.

"A man is well educated if he is in as good health as is possible for him, if he is able to make an honest living, if he exhibits good taste in his amusements and recreations and intellectual pursuits, and if he is tolerant of the opinions, ideas, and ideals of others. The study of biology contributes to all of these ends."

—A. E. Holch in *The Science Teacher.*

"The only effective relief [from loneliness] for men stationed far from home is an intelligent interest in their surroundings."—SIGERSON.

EYES THAT SEE

By WILLIAM C. SIGERSON[1]

THIS war has thrown a spotlight upon the failure of educators to provide our fighting men with the resources needed to sustain themselves in distant places. In outposts around the world where our forces are stationed, the most deadly foes are boredom and loneliness. Only a small part of the grim business of war is devoted to actual fighting; the major portion consists of preparation and waiting.

The only effective relief for men stationed far from home lies in an intelligent interest in their surroundings. Letters from home, planned recreation. USO shows and movies are not enough. Reading facilities are usually limited. But service men would not need large libraries to explore the strange environments they find about them. They would only need some previous interest and knowledge along scientific lines. Our educators have failed to provide them with these prerequisites.

The general lack of intelligent interest displayed by service men in things foreign is borne out in their letters and conversation. A friend stationed in New Guinea, with its 650 species of native birds, countless plants and unexpored geologic possibilities, writes that "It is a world of beautiful birds . . . and of lush ferns and palms." Here, interest exists, yet without sufficient previous knowledge to exploit it. The majority of letters even fall short of the interest level. How many service men have you talked to who could give adequate accounts of the places they have visited?

The barren atolls of the Pacific, the steaming jungles of New Guinea, the wastes of Iran and the uncharted mountains of Assam need not be living death for the men stationed there. Even the most outlandish foreign posts can be full of interest. Botany, zoology and geology are not the only possibilities. Anthropology, astronomy, archeology, meteorology, linguistics, economics, agriculture and many other broad fields of knowledge readily suggest themselves. The average service man fails to take advantage of these opportunities, and so regards a stay at a foreign post as nothing short of a complete personal loss.

The loss is not only that of a younger generation which has not learned to be aware of its surroundings. Human knowledge also suffers. Our troops are continually visiting new areas of the earth, or places only reached occasionally by explorers, or expeditions outfitted at great cost of money, time and energy. If proper interest and training existed, a stream of vital knowledge and material might be flowing back for the benefit of civilization.

[1]LIEUT. (j. g.) SIGERSON, U.S.N.R., is a born naturalist spoiled at Yale by a degree in Law. His present special duties with the U. S. Navy in the Pacific have afforded him a nature lover's truest happiness—new sights for his eyes to see. This article has been reviewed by the proper Naval officer and approved for publication.

Contact with natives might provide fundamental anthropological, sociological, agricultural, linguistic and historical data. The uncovering of ruins and fossils might fill out our knowledge of the history of life on earth. The discovery of new forms of plant life or new uses for plants might be of revolutionary importance in medicine, pharmacology, industry and agriculture. New geologic finds might contribute to the earth's dwindling mineral resources.

It is not suggested here that teachers should educate youth along scientific lines solely as a preparation for war and duty in foreign lands. The benefits are broader. The war has merely emphasized a situation which prevents our youth from living fuller and more useful lives. The logic of events makes it likely, however, that larger numbers of Americans will be travelling to all parts of the post-war world on a variety of missions. It will be important to themselves and to us all that they have the ability to observe and to learn from what they see.

It is the duty of educators, beginning at the grammar school level, to capture the interest and enthusiasm of American youth in scientific fields. To do this they must keep their subjects from being dull tours through text books. They must base their courses on an analysis and explanation of the familiar environments that the students are themselves living. Having once developed eyes that see, the pupils will be prepared to live useful and interesting lives in whatever parts of the world their destinies carry them.

"Great men do not create cultures, but cultures present great men with opportunities. Dante, Shakespeare, Beethoven, Edison, and Marconi respond to social tension and thus enable their fellow men to realize their dreams and aspirations. Great men appear in a community that is restless, progressive, dynamic, but rarely in a community that is stagnant, self-satisfied, inert."

—Waldemar Kaempffert in *Science Education.*

"The science needed by today's younger generation is notably different from that needed even five years ago."—McGRATH.

The Challenge *to* Science Educators

By G. D. McGRATH[1]

IF one were sufficiently interested to browse through the articles or reports of addresses contained in the periodical literature during the past ten years, well over thirty articles would be found which are devoted to a discussion of what lies ahead in science education. In these articles, over fifty separate suggestions or predictions are made.

It has been a pleasant thought for the science teachers to feel that leaders are keenly aware of the problems confronting science education, but perhaps equally disconcerting has been the fact that in so few areas could a solution be clearly visualized.

Arguments about method have persisted throughout and some have doubtless shut their eyes to changes which were outcropping, or have preferred to continue in the same old ruts.

A great many, too, have been fearful of the over-all effects that the war would have on science teaching. Others have felt it a splendid opportunity to make changes and adaptations with a view toward long range improvement. For anyone who holds that drastic changes in science education are inescapable, and who keeps his thinking rather fluently working toward smoother and more effective transitions, the conclusions that may be rather safely drawn at this point are indeed gratifying.

One may hope, of course, for the ideal of science courses that become self-buoyant in the enthusiasms and values they generate. Thus no science course would be terminal in itself, but a desire to ever learn more about science would be an outcome of all science instruction.

Our experiences with the Victory Corps, pre-induction courses, and various academic programs for the armed services have cleared some of the obscured views into the future. For one who has carefully analyzed the picture, certain practical conclusions may be drawn. It is indeed tragic that war seemed necessary as an agency to bring some of these points vividly to us, but if there are some silver linings in every cloud, perhaps we may as well accept better science teaching in the future as part of war's benefits.

It would be burdensome and undoubtedly a waste of time to attempt to re-evaluate all of the prognostic views or recommended changes that recent articles dealing with science teaching have stated, but there are thirteen in the group that might capably bear amplification in the light of the above assertions.

A tabulation of these thirteen statements follows:

[1]*PROF. McGRATH, Head of the Department of Science in the Boulder (Colo.) High School, has taught all the high school sciences, plus chemistry, physics, geology, and science education in the University of Colorado. To this he adds a "tour of duty" as instructor of U. S. Army Air Forces at Eastern Oregon College of Education.*

1. There should be better teacher preparation, including a better balance in training and better methodology.

2. The old argument of subject matter versus methods courses should be settled to the advantage of the teacher who is being trained.

3. There should be better and more effective methods for teaching pupils with abilities below normal.

4. We should resort to the teaching of principles and major generalizations instead of facts as ends in teaching.

5. There should be a well-integrated science program from the beginning of educative experiences, throughout the entire extent of school attendance.

6. The science courses taught should be better integrated toward the needs of daily living.

7. There should be some sort of state and national coordination of science teaching.

8. An entirely new concept of the function of laboratory work should be developed.

9. There should be extensive development of types and qualities of visual aids.

10. A far better testing program should be developed.

11. There should be well-understood, workable criteria for a well-conducted science program.

12. There will be great demands for science training in the area of adult education.

13. The most effective techniques and methods will be sorted from a motley array of procedures to the end that better choice can be made by science teachers in general. The teacher training institutions which can offer courses involving these methods will be in a most favored position.

Not one of these statements is meant dogmatically by the writer, but they merely summarize concepts suggested in available materials. Admittedly, many good teachers of science have long practiced and preached these ideas. Yet brief discussions of these statments seem pertinent.

Discussion of better teacher preparation is always an explosive issue. It is being demonstrated daily that a teacher of science needs better methods and better training. The science needed by today's younger generation is notably different from that needed even five years ago. A propitious learning situation challenges a teacher to use a variety of tested techniques, including literally every trick in the bag. This is a sustaining argument for more and better methods courses of the right kind. By the right kind, we mean those that actually analyze the problems a teacher faces, and show better methods of solution. Such methods courses also keep one abreast of the thinking of leaders in the field, and fortifies one with usable knowledge of enrichment materials, helps for clubs, exhibits, projects, demonstrations, etc. Good methods courses give a down-to-earth practical understanding of scientific attitudes, methods, and objective to attempt to inculate, and how to evaluate what is being achieved.

It is evident in connection with better teacher preparation that many institutions which train teachers will complain that there is no room in the training program for such courses. Science teachers have often requested deletion of some of the traditional, duplicate-reading, impractical, theo-

tical courses in favor of more helpful courses. An alternative might be the combination of several of these unwanted courses in a short term of work with emphasis on the highlights. Perhaps real curriculum revision should be carried out in teacher training courses as well as in the secondary level. If ever teacher training institutions desired an opportunity to clean their own curriclum back yards, now approaches a golden opportunity to think it through before the expected "land office" business after the war.

A second proposition is more or less an outgrowth of the first. We must admit at the outset that one cannot teach what he does not know. Fair minded educators, however, do not agree with the subject-matter diehards that "it doesn't matter how you teach it, just so you teach it." There would be no shorter road to disaster for science courses than to adopt that slogan. Again it is evident that "methods alone" is not the solution. There must be a compromise based on fairness and understanding. This means that some courses will have to be earmarked for substitution, combination or regrouping, while certain studies of method will be more favorably combined with the subject matter treatment.

Our war experiences have definitely taught us that our poorer pupils mentally can effectively learn much more than many thought possible, and can render genuine service to our national life. Even before the war many researches had been completed and much thinking devoted toward better methods for teaching students of but fair ability. Much of our war science teaching has been a proving ground for these suggested methods and they have been found excellent. The problem now is essentially one of acquainting more of our science teachers with these funds of desirable helps.

The old-style fact teaching has been dealt a severe blow in recent trends. We are learning that use of science knowledge depends on understanding a principle or generalization. This means that facts cannot be accepted as ends in teaching. Principles are both easily remembered and understood if built up with a host of applications in every avenue possible. One thing that is playing strongly into the hand of our armed forces is that many of our men have been trained in the understanding of major principles and when the answer is not found in a book of tables, they can apply the principles and pull themselves out of a hole through practical reasoning. In many instances, from fifty to eighty practical applications are connected to a principle taught to men in the armed forces. It facilitates meaning, recall, and ability to use the principle profitably. This is bound to have a profound effect on the teaching of science.

As better understanding of the science that will provide myriads of new comforts for man after the war becomes needed, more demand for a well-integrated science program from the first to the last grades will be in evidence. The schools will be charged with the responsibility of helping mankind enjoy the great new scientific developments after the war. A little science all along the way through each step of educational progress may be the answer. A well-integrated, gradually unfolding program may also have as a distinct objective the improvement of social and scientific atti-

tudes, and an appreciation of the better things of life.

The sixth premise grows out of number five and is closely allied with it. For science to be more practical and based on daily needs, we shall have to re-evaluate the contributions of all science courses now offered. Our present programs have indicated that fruitful parts of existing courses can be selected from the whole, leaving much material to be omitted. Since only a small percentage of our population needs specialized training, many of the newer courses will have greater popularity and contribution. These include such courses as astronomy, geology, meteorology, pre-flight aeronautics, radio and electricity, a new type of consumer education, mental hygiene, and practical psychology. It seems probable that there will be many elective science courses, possibly one semester in length, with the traditional ones being largely reserved for those who wish to specialize.

State and national coordination of science teaching has met rebuff or raised eyebrows from many educational thinkers on the grounds that it would mean dictatorial policy. The state and national coordination plan does not make this assumption logical. It has been well thought through by many leaders and many frankly believe that the impetus given science courses after the war will make the coordinator plan a realization. In its simplest form, it means that each state department of education would have trained leadership devoting efforts toward acquainting schools of that state with the latest ideas, techniques and contributions in each area of science. It would direct cooperative effort toward meeting problems of teaching science which has been found to be peculiar to that state. This would make for a more uniform treatment of vitalized science so that each instructor could, upon his own volition, profit by what has been learned that would improve his teaching. In turn, a national coordinator would act as a clearing house for interchange of helpful ideas and intercooperation. This could launch a whole new era of inter-school cooperation. Straws seem definitely in the wind for such a plan to have popularity after the war, and to be widely expanded in its services.

One of our biggest problems in science teaching has been an understanding of the function of the laboratory in a course and how to meet the manifold problems accruing from laboratory work. We can agree from recent experiences that laboratory work has little justification unless it is truly a discovery period. If the problems confronting a teacher in a laboratory are recognized by him, he can profit greatly by the researches and experimentation which have been worked out to answer these problems. Then laboratory work can truly facilitate learning, develop skills, and spice the course enthusiasm.

Army training on the academic level has focused our attention anew to the place visual aids should have in our teaching program. Their use, says a recent summarization by the Office of War Information, enables the men to learn more and faster, and remember longer. A new emphasis on working models is bound to have a decided effect on science teaching. Great developments are being worked out in this area.

That a good testing program takes much time and effort to develop, and

should be essentially a teaching device, has been the cry of forward looking science teachers for years. Comparisons and cooperative effort toward successful and valid examinations among schools in academic programs for the armed services have done much to improve the testing programs. Much research on validity and improvement, in general, of the testing program is developing currently and it should be ready to apply to the problem within a short time.

A more uniform set of criteria for evaluating just what is a well-conducted science program will grow out of comparisons, uniform directives, uniform objectives, and cooperative effort to achieve the most possible from the Victory Corps, pre-induction courses, and armed forces academic programs.

When these criteria are better understood, teachers will be more anxious to evaluate themselves and their offerings for betterment. This will have a stimulating effect on education generally.

All roads seem to point to more science in adult education. Many men returning from the armed services will expect a right to a better foundation in science to carve a better niche in the greater America to follow. One of the first items on the agenda for post-war governmental activity will be to make it possible for more of these men to pick up their educative experiences from a point of previous termination. In order to enjoy the good things to the fullest extent, older folks are going to seek more scientific knowledge. More and more is going to be expected from science as an educational contribution. The adult education problem must be met and offers a unique opportunity for skilful planning.

The specialized training programs for the armed forces have offered a veritable happy hunting ground for evaluating techniques, methods and procedures for presentation of classroom materials. In many programs, it has been possible to try one technique with one group and then try another technique with a similar group within a week or two. It has been easy to draw comparisons on method due to frequency of repetition. Excellent teachers have been drawn from schools everywhere for these programs and many of them have had ample opportunity to select varieties of approaches and try them under nearly every conceivable situation. Thus a methodology backed by actual experiences will filter into our science programs and the results promise to be highly effective. It is gratifying that some of this methodology is not a great departure from methods which have been used by many good teachers for years, although we can now feel more certain after these trials.

Thus science education is on a prosperous plateau which appears to lead ultimately to higher realms of service to mankind. We can now see quite clearly many of the avenues for improvement. We should not be nostalgic for the "good old days" in science teaching. By cooperative effort and foresight, we can pre-condition ourselves to be ready when the "new day" for the science teacher arrives. Perhaps it is here now. Let's accept the challenge!

"The lads who went to sleep while the falling apple made history at Sir Isaac's feet awoke with enthusiasm to calculate the velocity of a bomb fall on Tokyo."— EVANS.

Aviation: *Its* Place *in* Tomorrow's Curriculum

By RAY EVANS, Jr. *and* ELEANOR M. JOHNSON[1]

WHEN the Emperor's little yellow boys opened their bomb bay doors over Pearl Harbor, they certainly didn't realize that they were playing an important role in the advancement of American education. When the ruins of December 7th were cleared away, all far-seeing educators of this country realized they had a new teaching tool — and the pedagogues found a bomber in their classrooms!

When America entered the war, the leaders of the Army and Navy air forces turned to the leaders of American education and asked them to do the biggest teaching job in history. The schools were to throw their whole system into high gear overnight, and to produce the Air Age, full-blown, today! The result was as typically American as the Lockheed Lightning: fast, effective, and thorough.

And so the bomber came to the classrooms. Programs were devised, aviation classes sprang up in every school, and teachers spent their nights learning and their days teaching. Trade and textbook publishers called in the night shift to produce the materials required for this task.

The bomber in the classroom was not merely a flying machine to explain and dissect — it became the instrument which revolutionized the teaching of physics, mathematics, geography, chemistry, literature, economics, and politics. Enthusiasm is the one great key to successful teaching: if you can't hold the interest of your students, you can't teach them anything. The airplane provided this much-needed hypodermic.

The lads who went to sleep while the falling apple made history at Sir Isaac's feet awoke with enthusiasm to calculate the velocity of a bomb falling on Tokyo. The pupils who became bored with a discussion of the silicate deposits of California took a new interest in the development of magnesium, the magic metal, one-third lighter than aluminum. Geography took a turn for the better when it was discovered that the shortest route from Panama to Singapore lay north — not west.

Almost every phase of science has its applications in terms of aviation. Do you want to know about Pascal's

[1] *Versatile MR. EVANS flies his own plane (when permited), writes the text, and draws the pictures for "Current Aviation" —the weekly classroom paper that has contributed so much to pre-induction courses in aeronautics. MISS JOHNSON is the alert and experienced Managing Editor of "Current Aviation," "Current Science," and other papers of the American Education Press, Columbus, Ohio.*

principle of hydraulic pressure? Then study the elevator controls of a B-24. Do you want to understand the gas laws of Charles and Boyle? Then watch the piston in an Allison engine. Do you want to know the reasons behind Newton's laws of motion? Then observe an Airacobra making a steep bank. Better than that, calculate the angle of bank yourself — and a simple diagram will show you how to do it.

Pre-flight students learned the types and methods of construction of the various kinds of planes. They learned how aircraft engines work, and how to make calculations for horsepower and propeller thrust. They had a working knowledge of the latest carburetors, superchargers, and pitch-control systems. The whole field of aerodynamics, which really is the study of fluids and forces, was made so clear that most students easily could calculate lift, drag, required horsepower, and angle of glide.

In the all-important field of meteorology, students learned how to construct and use weather maps by the new air-mass data. They knew how to evaluate weather signs, and to forecast probable weather conditions.

They learned how a flight is planned, in detail, and step by step. They were able to solve practical problems in dead reckoning, and, as a final problem, they planned a flight from Seattle to Tokyo, and plotted their position, in mid-ocean, on a Navy plotting sheet from celestial observations. In the meantime, students had acquired a basic knowledge of the fundamentals of radio, with particular applications to aviation.

What Claim Has Aviation to a place in the Curriculum?

But — you will say — aviation education in the junior and senior high schools of tomorrow must not be a technical preflight aeronautics type of thing such as is depicted in the paragraphs above. The wartime importance of preflight aeronautics and the consequent stress placed thereon are no criteria for determining the place of aviation education in tomorrow's curriculum.

It is appropriate and timely, therefore, to evaluate the potential values of aviation education in our schools. Why include aviation at all?

1. *Aviation education is functional.* Aviation is having and will continue to have great impact on our social, political, and personal lives. Because of the technical advances made to date in aviation, we find our lives tremendously modified in many of its major aspects.

We are well into the age of flight. The airplane has shrunk our world and will continue to shrink it. With the giant cargo planes of the future and the international transport lines, we are going to be forced to live in close proximity to the other peoples of the world.

We are fast becoming aware of the influence of the airplane on the health, safety, commerce, culture, and recreation patterns of peoples everywhere.

A curriculum cannot ignore the facts of human living without serious results. Our curricula must provide young people with experiences, ideas, and knowledge appropriate for effective living in a world influenced by the modern airplane.

2. *Aviation is of general interest to young people.* Children of all ages want to know more about aviation.

The Stanford School of Education[2] recently made an investigation of children's questions on aviation. The study showed a wide range of interests, questions, misconceptions, and ideas on which the students wanted informed and intelligent assistance.

Any teacher knows how common are these questions, interests, and the vast amount of knowledge students have about aviation. Here is a subject which is self-motivated. Can we offord to ignore these interests and fail to give them their place in the curriculum when we continuously give lip service to students' interests in our educational philosophy and theory, particularly when these interests coincide with modern social values and the march of human progress.

Other values for aviation education might be listed. The listing could be made quite long and well defended, but the two given above are basic criteria for admission to any curriculum.

Schools which recognize the part aviation is playing (and will continue to play) in human life have shown that they can adjust schedules and curricula to meet new social demands.

Many teachers are fitting aviation into their regular courses of study. Teachers are discovering that they can present successfully hitherto unfamiliar materials which are vital to current human living and thinking. Nine times out of ten, instructors are finding that aviation introduced into the science courses quickens youth's interest and leads to adventurous achievement.

Schools everywhere are discussing their experiences with aviation education and projected future developments. At least nine state departments have already issued new courses of study in aviation education extending from the kindergarten through junior college.

Summary

In order to be functional science teaching must be directed toward better living.

There is nothing new in the *theory* of relating science teaching to the solution of personal and social problems of everyday life. However, if better living is to result, science education in *practice* must concern itself with technological advances in various areas of science and their applications to human betterment.

Aviation is merely one area that is asking for admission to the curriculum. Numerous other areas — safety and health, consumership, recreation, conservation, etcetera — present unlimited opportunities for broadening the prospective of science education.

2 California Journal of Secondary Education, October, 1944, p. 288.

"Rejections in the military service have again emphasized the need for more educational concentration upon health."—HURD.

POST-WAR HEALTH EDUCATION

By ARCHER WILLIS HURD[1]

A SHORT time ago, in response to a request to express my views on needed post-war education in science, I proposed reorganization of all courses in our public schools around the challenging problems of contemporary life. Health is one of the most important of these problems. One writer has said, "With health, everything is a source of pleasure; without it, nothing else, whatever it may be, is enjoyable. It follows that the greatest of follies is to sacrifice health for any other kind of happiness, whatever it may be, for gain, advancement, learning, or fame, let alone, then, for fleeting sensual pleasures." Health has always been placed high in the list of educational objectives. It is still a challenging problem of contemporary life. Rejections in the military service have again emphasized the need for more educational concentration upon Health. The problem is still largely unsolved. What can we do to take it out of the realm of mere statement of importance and direct dynamic efforts toward its functional reality in individual and community life? Not only health precepts and health doctrine but health habits and living?

First of all, ways must be found to make it possible and wise for instructors to build school courses to fit the health conditions found in the community in which the school is located. A survey of health needs by health instructors would set the stage for more functional courses in the particular setting. At present, instruction is too firmly bound down by outmoded courses and curricula which were not planned definitely to bring about healthful behavior in the specific community. Educators are coming to see that there must be specific attention in school work to behavior, if full function in right living is ever to be attained.

Second, the pupil himself must be conceived as a functioning individual with problems to solve and decisions to make. He cannot be made to live healthfully by being taught a few "rule-of-thumb" exercises, or habits. He lives in a complicated world of good and poor food; honest and dishonest dispensers of foods, drugs, and patent medicines; advertising of the good and poor variety; appeals to good and bad impluses; invitations to helpful and harmful activities. He must learn to distinguish between the two phases and choose the better. He must learn to weigh values and find the good way to physical and mental health by utilizing his powers of intellect in his

[1]*DR. HURD is Director of the Bureau of Educational Research and Service, Medical College of Virginia, Richmond, Va. In his previous positions he outstripped his fellow science educators in the number of scholarly studies he completed and published. In his present position he will doubtless concentrate on health problems —a good omen for health education.*

choices. Good health must be identified and defined by teachers and pupils working together in activities initiated toward discovering and following the path that leads in this good direction.

Knowledge and information are necessary and they must be secured from the best available sources. Reading, studying, discussing, practicing — all of these must be incorporated into school courses. Pupils must be taught to realize that they will always be confronted with personal problems they must solve in order to be healthy and happy. So they must be educated in the elements of problem solving in general and health problems in particular. The matter of health is so vital that there must be definite courses designed to accomplish the needed objective. Education for the consumer, and education to detect propaganda will be part of the subject matter of health courses. And these courses must be sequential from school grade to grade to make health education continuously prominent in the minds of boys and girls.

Another area to emphasize is one including causes and prevention of diseases. This should be common knowledge and not left to doctors and nurses alone.

Then there must be continued and improved preparation of good doctors, nurses, and other specialists in health practices and disease prevention. Research to discover new elements which make for, or destroy, health must be continued and even accelerated. We still do not known enough about mental and physical ill health — its causes and cures. But the population at large must not be taught to depend on doctors, dentists, nurses, and pharmacists alone for its own good health. Its importance is so great that individuals may learn some of its principles and use them more profitably than they use some of the principles of parsing, cube-root, and quadratic equations which some of them try so hard to understand without much success.

Where shall the consecutive courses in health be placed in the public school curriculum? We have probably given wrong emphasis to the three R's in our schools in the past. If the common problems of contemporary life were made primary in school work, reading, writing, and arithmetic would be needed all the way along, but they would be rightly thought of as needed tools — not as ultimate aims and objectives. Time would necessarily have to be taken to teach pupils to use these tools but major attention must be directed toward right and good living. The reasons for reading, writing, and computing as tools would then always be in the focus of purpose. This would perhaps lend added motivation toward learning to use these tools more quickly. Science would be involved from the very beginning. What is science but systematic thinking through problematic situations? To be sure, in its later specialized stages it concentrates on definite fields but, even then, it realizes its place in the functioning individual and social lives of people.

A plan of teaching which seems best adapted to pupil growth and development is a unit-problem-project plan. Teaching units which are arranged to make definite generalizations concerning everyday life will be set up in courses with challenging titles of a concrete and practical nature. Men and women, boys and girls, families, houses, villages, cities, telephones, rail-

roads, automobiles, radios, animals, plants, character in good living, religion, churches, and so on, would receive attention in these courses and units. Economy and convenience in thinking would be taught through processes of generalization as the child accumulates enough sense impressions to relate and classify.

The process of solving problems systematically would begin early in school. Details would be relegated to their proper places and important facts and principles be emphasized. Problems, including those related to health, would constitute the major portion of the teaching unit.

The use of individual and group projects initiated by pupils themselves —guided and directed by wise instructors—would begin early. These projects would provide for individual competency, practice in individual planning, and the proper development of personal responsibility in meeting the problems of everyday living, and securing improved living conditions for all. Due recognition in appropriate form should be extended to those who evidence particular excellence in their vision and initiative, and should not be withheld from any pupil.

Health must be kept prominent in all courses and units, for it is a major objective. We have often said that, if we are to have good spoken and written English, we must teach English in all classes. A similar statement may wisely be made with reference to health. But there must be basic courses in health.

Summing up these concepts, this is what I have tried to say concerning post-war health education.

(1) The total school curriculum should be reorganized around everyday contemporary problems of boys and girls — individual and social — not around the tool subjects.

(2) Some courses will be organized around individual and community health.

(3) Units and other references to health shall appear in many other organized courses throughout the curriculum.

(4) Tools — such as reading, writing, computing, scientific problem solution — will be considered and used as tools to bring about better and more complete individual living in an improved social environment.

(5) The aim of schooling will be recognized as the search for more satisfying individual and community life.

(6) All course and unit objectives will be contributory toward achieving this major aim.

(7) Personal responsibility and initiative in carrying one's own share of obligation in promoting better living for all will be particularly emphasized.

(8) Health will be recognized as a foundation necessity and should be the center of organization in some courses and units within many other courses.

Do you say idealistic and impracticable? Beginnings have already been made in some school programs. I have before me now a 576-page book entitled, *Health for You*[2] being used in a large city high school, and a suggested teaching unit, *The Health of a Nation*[3]. We are beginning to realize

2 Katherine Bruderlin Crisp. "Health for You." Philadelphia: J. B. Lippincott Company, 1944.

3 Michael M. Davis, Bernhard J. Stern, and Lavone A. Hanna. "The Health of a Nation." Problems in American Life: Unit No. 17, National Association of Secondary-School Principals, National Council for the Social Studies, Washington, D. C., 1201 Sixteenth St., N. W.

that purposes are the important things to determine before we start out to educate boys and girls—citizens of the world of tomorrow.

When the primary purpose of all education is to build a better, a more happy, a more satisfactory world, and man recognizes that it is his privilege and honor to contribute, and that the responsibility rests alone with him, there will be more logic in the educational system he fashions for his children. Mental and physical health, growth, and development will be near the head of the list of school objectives and the program planned systematically to achieve that purpose.

"The chances of one's writing anything of permanent value before one is thirty are small. One wastes valuable themes trying to make a living. It is better to adopt any occupation which will give you a living and some experience, and write on the side."

—William Somerset Maugham

EDITORIAL

The Educational Stew *is* Boiling

By CARL G. MILLER

SPRING of 1945 finds the educational stew boiling vigorously. Army and navy officials take occasion to throw on the fire more sticks of criticism regarding the failure of education to do better with the health and stamina of America youth. And educators bubble back the best reply they can. Arguing endlessly, the "old guard" in liberal education plead for the renewal of their curriculum. Sponsors of vocational education speak forth their demands and show how important is their program in carrying out the G. I. Bill of Rights. Anti-Progressives take another fling at the old liberal group and pop goes a greasy bubble as it bursts. A few diehard Progressives rise in heat to defend their views and take a crack at a conservative like Hutchins of Chicago. The N. E. A. asks Congress for three hundred million a year to equalize school support among the states and crack! crack! is the comment for and against. According to a newspaper editorialist in Spokane, teachers should be given the privilege of working at a low salary for the love of the profession. Educators, in other words, are like crusaders. The argument over compulsory military training, with its implications for all education, steams up and almost spoils the top of the stove by its boiling over. And so the stew boils on and will boil on for several years after the war. Maybe by 1950, when America will have a considerably modified educational plan, the stew will have cooled off.

Looking at the pot from a distance, one can make a few observations but nothing conclusive, nothing like removing the key logs from a log jam and sending the pile smoothly floating down the river. One thought is that education is like politics. There is a liberal group and there is a conservative. There always will be. The one will always look upon the scene and the problems in a light different from the other. Maybe it's a good thing. But the good old policy to follow will be the middle road. Another thought is that in the new arrangements for education we should place responsibility for a certain result with a certain unit, and then by Jove! hold that group responsible for the result we want. If, for example, the group that balks at compulsory military training this time wins out and a quarter of a century hence the United States is again at war, let's find the persons who failed by their program to avoid it, or to prepare for it, and give them their just dues. Those "peace preachers" of the past who helped to delude us about the approach of the present war are a notable example of what to avoid in the future.

BOOK REVIEWS

Historic Currents in Changing America. By H. J. Carman, W. G. Kimmel and Mabel G. Walker. The John C. Winston Company, Philadelphia, $3.00.

This is a history of America by three unusually capable teachers, all of whom have had extensive experience in teaching the subject for which this textbook was designed, that is, to acquaint pupils in high school with our history and problems.

Dr. Carman is well known as a brilliant historian, who first came into prominence as the author of "A Social and Economic History of the United States." What J. R. Green did for the history of England, Dr. Carman has done for the history of America and is therefore in the forefront of American historians.

Dr. Kimmel is a real scholar, who was, for a few years, an instructor in the high school at the University of Chicago and later became a supervisor of Social Studies in the New York Education Department. For five years, from 1929 to 1934, he was an executive secretary of an important committee of the American Historical Association.

Dr. Walker is a lady of keen insight and broad culture, who has had much experience as a teacher of history and related subjects. She was well prepared to do her share in producing this splendid treatise as she has devoted many years to research in history, sociology, economics, and government. However, since she "likes people" her work as a scholar never dulls her interest in practical problems.

James Bryce holds that "for the highest kind of historical work four gifts are needed: (1) unwearied diligence in investigation, (2) a penetrating judgment which can fasten on the more essential points, (3) an imagination which can vivify the past, and (4) that power over language which we call 'style'."

Further. James Bryce contends that the greatest historians combine "a wide sweep of vision with a thorough mastery of details" and are able "to set forth both the details and the principles in a way which makes them enrich the reader's thought, touch his emotions and live in his memory."

The authors of this volume have, in a marked degree, all of these essential qualifications. As a result we have a superior textbook: a vitalized portrayal of American history with emphasis on our social, economic, cultural, and political conditions, and their relation to the working of our increasingly complex government.

The work is in harmony with the very best theory of the place of the social studies in secondary education. The book deals, in a cogent manner, with social progress and cultural evolution. It is evident from the outset that the authors realize that the task of the historian is to interpret the main fields of human activity which have contributed so much to American civilization.

Since wars and politics are often closely related to the growth of society, and affect human welfare, they have not been neglected, but greater emphasis than hitherto has been placed on the arts and occupations of peace: on science, customs, religion, pacifism, morality, painting, education, inventions, industry, commerce, democracy, radicalism, militarism, nationalism, imperialism, philanthropy, and humanitarianism.

The problems which confront our thinkers at present are discussed in a masterful manner. Among the subjects which receive unusual emphasis are "world affairs," "relief measures," "currency problems," economic legislation, agrarian discontent, proletarian movement, foreign relations, isolation problems, American investments, neutrality difficulties, and international misunderstanding. Disputed questions are dealt with dispassionately.

The work is admirable in its dignity and lucidity. Yet this is no milk and water text: it contains real meat for alert students; and it is written in a most engaging manner. It is a dynamic history:

there are very few dull pages in the entire book. It is, indeed, a graphic and absorbing narrative, full of striking sentences and thrilling paragraphs.

The work is eminently teachable. Each unit and every chapter closes with activities which consist of problems, questions for debates, subjects for "floor talks," and themes for those who may possibly become journalists. These activities are always accompanied by selected references. Pupils who are fortunate enough to use this book will be profoundly grateful to the authors who have written this masterful synthesis.—Reviewed by R. Andrew Mackie, Ph. D.

The Cambridge Economic History of England. Vol. I The Agrarian Life of Middle Ages, Edited by J. H. Clapham and Eileen Power, New York, Cambridge University Press: The Macmillan Company, 1944, XVII and 650 pages, $7.00.

This monumental work, planned on a great scale, tells the economic history of the world as it impinges upon Europe, starting with the later centuries of the Roman Empire. Complete in itself this particular volume gives the fundamental geographic, economic, and social bases of medieval life. The earth, the crops, the toil of the peasants, how villages and fields were occupied and laid out, how and with what cattle and implements they were tilled, what the society was that they maintained—all such factors are considered in detail and their influences noted. The great sweeping movements are considered in general chapters and these sections are supplemented by regional studies. The staff of contributors were selected in 1934 when the first three volumes were planned. The continental authority of the first volume has not been destroyed by the War but it is more than likely that the scholars selected for the remaining volumes will never be together to complete their labors. Scholarship is definitely a war casualty, but Germans had this in mind all the time.

This lucid presentation of such an immense range of detailed knowledge can take its place as a landmark in its field.—William P. Sears, New York University.

The Completion of Independence, 1790-1830 by John Allen Kraut and Dixon Ryan Fox, New York, The Macmillan Company, 1944, XXIII and 485 pages, $4.00.

With the appearance of this volume, *The Completion of Independence, 1790-1830*, the ten-volume series *A History of American Life* (edited by Arthur M. Schlesinger and Dixon Ryan Fox) is now complete. As a full-scale history of American life, this series is authoritative, authentic, and accurate. The present volume covers the period of the early decades of the republic and traces the interaction between the *mores* of the old world and the life of the new in the forging of an individual culture that is recognized as genuinely American. Life in town and country, on farm and plantation, political and economic developments, the rise of the professions, scientific achievements, and the aspirations and achievements in culture are described in rich detail. Of especial interest is the attention paid to the growth and development of education as a part of the American pattern. As in all volumes of the series, a fine chapter deals with a critical appraisal of the source materials—both the non-literary and the literary.—William P. Sears, New York University.

NEW RECORDS

Shostakovitch: Sonato for 'Cello and Piano. Gregor Piatigorsky, cello and Valentin Pavlovsky, piano. Columbia Masterworks Set M-MM-551. Three 12-inch records. $3.50.

The music of this young Soviet composer is becoming more popular every day. The great Russian 'cellist, Gregor Piatigorsky, gives a masterful interpretation of Shostakovitch's *Sonata for 'Cello and Piano* in this very interesting recording. The *Sonata* was composed in 1934 and this is the first recording of the work. Though unmistakenly modern in construction, the *Sonata* abounds in melody, and there are a number of themes in its four movements that are extremely beautiful.

Mozart: Concerto No. 24 in C Minor for Piano and Orchestra. (K. 491). Robert Casadesus, piano, with the Orchestra Symphonique de Paris, conducted by Eugene Bigot. Columbia Masterworks Set M-MM-356. Four 12-inch records. $4.50.

There can be no better example of 18th. century music for classes in music appreciation than a Mozart concerto. Columbia, pursuing its traditional policy of selecting a fine set from its catalog and bringing it before the public for additional consideration, provides just the concerto for school purposes. It is the *Concerto No. 24 in C Minor* of Mozart brilliantly interpreted by Robert Casadesus. Mozart wrote twenty-seven concerti for piano and orchestra in all. The piano was the favorite instrument of Mozart and the majority of the concerti were written to be played by Mozart himself. In fact, Mozart's audiences came to expect a new concerto at every concerto. The *Concerto No. 24* was composed in Vienna in 1786. The concerto is in a minor key, being one of two written so, and is tinged with melancholy and deep emotion. Here is none of the gay, frothy writing that so frequently characterized Mozart. The whole concerto, however, is permeated with the inescapable charm and polished elegance of Mozart's compositions.

Treasure Island (Robert Louis Stevenson—Adaptation by Ralph Rose). Basil Rathbone, with supporting cast and chorus conducted by Richard Davis. Columbia Recording Corporation. Set M-MM-553. Three 12-inch records. $3.50.

Here is a very fine recording of Robert Louis Stevenson's ever fresh and invigorating tale of adventure and buried treasure. In this album, Basil Rathone, star of stage and screen, assisted by a competent cast brings to life the story of Billy Bones, Long John Silver and the other characters so vividly drawn by Stevenson. This is an album that all teachers of English in our elementary and junior high schools will want to have for their classes. Columbia is to be commended for bringing out this unique album. There can be no doubt but what if this album is received by school people to the extent that it should be, there will be similar albums in future Columbia releases. The teaching of literature may, in the schools of tomorrow, be a far more lively experience for pupils because of the gramophone and fine recordings.

Tchaikovsky: Hamlet — Overture-Fantasia, Constant Lambert, conducting the Halle Orchestra, Columbia Masterworks Set X-243. Two 12-inch records. $2.50.

Tchaikovsky was singularly attracted to the plays of Shakespeare, and he based musical works on three of them—*Romeo and Juliet*, *The Tempest* and *Hamlet*. It was during the summer and autumn of 1888 that Tchaikovsky, then at the height of his creative powers, composed the *Hamlet* Overture—Fantasia. The work was first performed at a concert of the Imperial Musical Society in St. Petersburg on November 24, of that year. Tchaikovsky conducted and the work was well received by the critics and the "first-night" audience. The music is brilliant and exciting and in this recording by the English composer-conductor, Constant Lambert and the Halle Orchestra of Manchester (England) all the fiery beauty of the score is faithfully reproduced. This is another fine recording for school libraries.